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USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-41
1975

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U.S. Forest Products Trade Policies:

WHAT ARE THE OPTIONS ??????

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PORTLAND, OREGON

Abstract

Trade and other policies are being considered by the U.S. Forest Service according to the terms of the Forest and Rangeland Renewable Resources Planning Act of 1974 (Public Law 93-378,93d Congress, S.2296). This paper describes the issues involved in the question, "Should we or should we not attempt to reduce net imports of forest products?"

In terms of volume, net imports of forest products amount to about 12 percent of U.S. consumption. The value of imports exceeds the value of exports by about $1.5 billion. Most of U.S. softwood imports come from Canada and hardwoods from South Korea, Taiwan, Japan, and the Philippines. Japan and the Common Market countries are the major markets for U.S. forest products exports.

Without a change in trade policy, net imports of forest products may increase. Constraints on options for increasing exports or decreasing imports limit the feasibility of policies designed to change existing and expected trade patterns.

Policies should be weighed in terms of their effects on both international and domestic goals. Most effects of changes in either import or export policies would be due to increases in the relative prices of forest products.

There is no clear rationale, either in theory or in existing U.S. trade policy, for balancing imports and exports of a commodity.

KEYWORDS: Import/export (forest products), trade policy.

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Preface

Analysis of U.S. trade policy necessarily involves many sensitive issues. The author's evaluation of these issues may not correspond with U.S. Forest Service or other Federal policy.

There is no unanimity of opinion among analysts of forest products trade policies on many of the issues which have been raised in this paper. The paper has been published because of the wide interest in the subject matter. It is intended for use as a background report and should interest members of the forest products industries and others who are affected by forest products trade policies.

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Introduction

The United States has a complex mix of national and international goals. The potential for achieving these goals is determined by policies which guide the allocation of natural resources within the world economy. World trade in natural resources, including those from the forest, is growing. The options available to change the current pattern of trade in forest products should be part of any assessment of U.S. timber policy issues.

The purpose of this report is to describe both the options available and the constraints on these options. The report is structured to provide a background of the role of forest products trade in the U.S. economy and the issues involved in framing policies, before the questions of policy options and constraints are discussed.

U.S. forest products trade in perspective

TRENDS IN NET IMPORTS

Ties between the Canadian and U.S. economies have made the United States a longstanding net importer of forest products. Trade has been concentrated in softwood products; most of the imported volume has been lumber and newsprint from Canada.

After relative stability in the 1950's, domestic production, consumption, and trade increased (tables 1, 2, and 3). By the 1970's, exports were over four times the level of the 1950's and imports more than double. Although imports remained concentrated in softwood lumber and newsprint, imports of pulp and hardwood veneer and plywood increased. Most of the increased export volume was in pulp and paper products and softwood logs. Increases in exports and domestic production have kept net imports relatively stable at 10 to 12 percent of domestic consumption as shown by the following:

Year	Net imports as a percent of consumption
1950	13.9
1951	12.1
1952	11.7
1953	12.3
1954	12.0
1955	12.1
1956	12.1
1957	11.8
1958	12.2
1959	12.5
1960	12.0
1961	12.5
1962	13.5
1963	12.5
1964	11.5
1965	11.6
1966	11.8
1967	10.4
1968	10.4
1969	11.1
1970	8.7
1971	12.0
1972	12.3
1973	12.2

Sources: Phelps and Hair (1974).

In terms of value, the annual forest products trade deficit (imports minus exports) fluctuates in response to changing market conditions but has generally stayed within the $1 billion to $1.5 billion range as shown in the following tabulation. The relatively low deficit in 1970 reflects increased domestic production of pulp-based products, increased log exports, and decreased imports of all products.

TABLE 1.—*Production, imports, exports, and apparent domestic consumption of timber products, by major product, 1950-73*[1]

(Million cubic feet, roundwood equivalent)

Year	All products		Industrial roundwood used for—																			
			Total				Lumber				Plywood and veneer				Pulp products					Logs		
	Domestic production	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports[2]	Exports[2]	Apparent consumption	Miscellaneous products[3]—apparent consumption	Imports	Exports	Fuelwood—apparent consumption
1950	10,795	12,180	8,525	1,520	140	9,910	5,905	535	80	6,360	345	5	(4)	350	1,500	935	50	2,385	770	45	10	2,270
1951	10,970	12,180	8,740	1,465	260	9,950	5,780	390	155	6,020	390	10	(4)	400	1,825	1,025	90	2,765	730	35	15	2,230
1952	10,780	11,940	8,775	1,375	215	9,935	5,820	385	115	6,095	435	10	(4)	440	1,810	945	85	2,665	700	30	10	2,010
1953	10,710	11,940	8,790	1,420	190	10,020	5,710	430	100	6,040	475	15	(4)	490	1,910	935	70	2,775	675	40	20	1,920
1954	10,590	11,780	8,755	1,460	270	9,945	5,635	480	110	6,000	480	30	(4)	505	1,960	920	135	2,745	655	35	25	1,835
1955	10,970	12,240	9,225	1,610	340	10,495	5,785	560	130	6,215	575	40	(4)	615	2,200	975	180	3,000	630	35	25	1,745
1956	11,275	12,605	9,620	1,640	310	10,950	5,920	530	120	6,330	590	45	(4)	630	2,475	1,040	160	3,355	605	30	30	1,655
1957	10,180	11,335	8,615	1,490	335	9,770	5,100	460	130	5,435	560	45	(4)	605	2,350	960	185	3,125	580	25	25	1,565
1958	10,010	11,195	8,530	1,495	310	9,715	5,160	530	115	5,575	615	50	(4)	665	2,165	895	165	2,895	560	15	30	1,480
1959	10,780	12,125	9,390	1,700	355	10,735	5,745	635	120	6,260	720	75	5	790	2,355	970	195	3,130	535	20	35	1,390
1960	10,220	11,445	8,920	1,675	455	10,145	5,080	610	135	5,560	705	60	(4)	765	2,575	985	275	3,290	510	20	45	1,300
1961	9,960	11,210	8,745	1,745	495	9,995	4,945	665	120	5,485	765	60	(4)	825	2,475	1,000	295	3,175	490	20	75	1,215
1962	10,160	11,570	9,035	1,910	495	10,450	5,120	760	120	5,765	800	75	(4)	875	2,565	1,055	295	3,330	465	20	85	1,125
1963	10,615	11,975	9,560	1,990	630	10,920	5,355	830	135	6,050	870	80	5	950	2,670	1,060	340	3,390	515	15	150	1,055
1964	11,155	12,470	10,170	2,035	720	11,485	5,635	815	150	6,300	960	90	5	1,045	2,865	1,120	395	3,585	540	10	170	985
1965	11,455	12,845	10,540	2,100	715	11,930	5,670	815	145	6,340	1,030	100	5	1,125	3,095	1,175	380	3,890	560	10	190	915
1966	11,490	12,920	10,645	2,230	800	12,075	5,645	810	160	6,295	1,030	115	5	1,140	3,190	1,290	420	4,060	565	15	220	845
1967	11,185	12,395	10,410	2,160	955	11,615	5,360	800	175	5,985	1,030	110	10	1,130	3,190	1,240	460	3,970	515	15	310	775
1968	11,725	13,005	11,025	2,395	1,120	12,305	5,630	960	180	6,405	1,120	165	10	1,275	3,385	1,260	525	4,120	485	15	405	700
1969	11,620	12,990	11,000	2,515	1,140	12,370	5,535	980	180	6,340	1,050	180	20	1,205	3,585	1,340	570	4,355	455	15	375	620
1970	11,660	12,725	11,115	2,420	1,355	12,180	5,355	955	200	6,110	1,065	170	15	1,220	3,835	1,275	710	4,405	425	25	430	540
1971[5]	11,600	13,120	11,100	2,695	1,175	12,620	5,495	1,135	165	6,465	1,235	210	15	1,425	3,560	1,335	630	4,265	450	15	360	500
1972[5]	11,935	13,535	11,460	3,000	1,400	13,060	5,650	1,405	215	6,840	1,355	265	25	1,590	3,495	1,320	665	4,150	475	5	495	475
1973[5]	12,330	13,970	11,830	3,065	1,425	13,470	5,680	1,425	295	6,810	1,360	220	40	1,540	3,775	1,415	575	4,615	500	5	515	500

[1] Columns may not add to totals because of rounding.

[2] Includes pulpwood and the pulpwood equivalent of wood pulp, paper and board.

[3] Includes cooperage logs, poles and piling, fenceposts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

Source: Table 2, Phelps and Hair (1974).

[4] Less than 2.5 million cubic feet.

[5] Preliminary estimates.

Sources: Based on data published by the U.S. Departments of Commerce and Agriculture. Data for 1900-49 in *The demand and price situation for forest products, 1964*, table 2 (Hair and Ulrich 1964).

TABLE 2.—*Production, imports, exports, and apparent domestic consumption of softwood timber products, by major product, 1950-73*[1]

(Million cubic feet, roundwood equivalent)

Year	All products		Industrial roundwood used for—																			
			Total				Lumber				Plywood and veneer				Pulp products					Logs		
	Domestic production	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports[2]	Exports[2]	Apparent consumption	Miscellaneous products[3]—apparent consumption	Imports	Exports	Fuelwood—apparent consumption
1950	7,155	8,435	6,615	1,395	110	7,895	4,780	490	65	5,205	185	(4)	(4)	185	1,285	880	45	2,120	360	25	5	540
1951	7,220	8,325	6,690	1,325	220	7,795	4,600	350	135	4,815	195	(4)	(4)	195	1,545	960	75	2,430	340	15	10	530
1952	7,315	8,400	6,840	1,260	170	7,925	4,715	355	90	4,980	250	(4)	(4)	245	1,540	885	75	2,350	325	20	5	475
1953	7,280	8,420	6,835	1,290	150	7,975	4,610	395	80	4,925	300	(4)	(4)	295	1,595	880	60	2,415	320	20	15	445
1954	7,220	8,330	6,805	1,330	220	7,915	4,550	445	90	4,905	315	(4)	(4)	315	1,615	865	110	2,365	310	20	15	415
1955	7,525	8,705	7,140	1,450	275	8,320	4,630	520	100	5,045	390	(4)	(4)	390	1,800	920	150	2,570	300	10	20	385
1956	7,790	9,010	7,435	1,465	250	8,655	4,700	490	90	5,100	400	....	(4)	400	2,020	970	135	2,855	295	5	25	355
1957	7,125	8,185	6,795	1,325	270	7,855	4,215	425	95	4,540	395	(4)	(4)	390	1,890	895	155	2,630	285	5	15	330
1958	7,030	8,125	6,725	1,340	245	7,820	4,240	495	85	4,650	460	(4)	(4)	460	1,730	840	135	2,435	275	5	20	305
1959	7,660	8,875	7,380	1,500	280	8,595	4,725	585	95	5,215	560	....	(4)	555	1,800	910	155	2,555	270	5	25	280
1960	7,180	8,320	6,925	1,500	360	8,065	4,125	570	110	4,585	550	(4)	(4)	550	1,960	925	220	2,665	255	5	35	255
1961	7,040	8,220	6,810	1,580	400	7,990	4,035	625	95	4,565	615	(4)	(4)	615	1,850	940	235	2,555	250	10	65	230
1962	7,190	8,495	6,980	1,705	400	8,285	4,150	715	100	5,765	650	(4)	(4)	650	1,870	980	230	2,625	240	5	70	210
1963	7,530	8,795	7,330	1,785	515	8,595	4,265	785	115	4,930	725	(4)	(4)	725	1,935	990	260	2,660	270	5	135	200
1964	8,010	9,230	7,820	1,810	595	9,040	4,530	765	125	5,170	800	(4)	(4)	800	2,050	1,045	305	2,785	285	(4)	160	190
1965	8,290	9,565	8,110	1,860	590	9,385	4,530	765	120	5,175	870	(4)	(4)	870	2,240	1,095	290	3,040	300	(4)	175	180
1966	8,290	9,580	8,120	1,955	665	9,410	4,465	745	135	5,075	900	5	5	900	2,245	1,200	320	3,125	310	5	205	170
1967	8,150	9,270	7,995	1,925	805	9,115	4,230	750	150	4,825	895	5	5	895	2,290	1,165	355	3,100	285	5	290	160
1968	8,755	9,890	8,615	2,090	955	9,750	4,535	905	165	5,275	985	5	5	980	2,445	1,175	400	3,220	265	5	385	140
1969	8,595	9,770	8,470	2,145	965	9,645	4,395	915	160	5,150	920	5	15	910	2,540	1,220	430	3,330	250	5	360	125
1970	8,760	9,700	8,655	2,090	1,150	9,590	4,270	900	180	4,990	950	5	10	945	2,790	1,165	540	3,410	230	15	420	105
1971[5]	8,765	10,095	8,665	2,315	985	9,995	4,435	1,080	140	5,380	1,105	5	15	1,085	2,530	1,220	480	3,270	245	10	350	100
1972[5]	9,030	10,405	8,940	2,555	1,180	10,315	4,610	1,340	175	5,775	1,205	10	20	1,200	2,390	1,205	510	3,085	260	(4)	475	90
1973[5]	9,270	10,700	9,170	2,645	1,220	10,600	4,645	1,345	260	5,725	1,215	10	35	1,190	2,555	1,295	440	3,410	270	(4)	485	100

[1] Columns may not add to totals because of rounding.

[2] Includes pulpwood and the pulpwood equivalent of wood pulp, paper and board.

[3] Includes cooperage logs, poles and piling, fenceposts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

Source: Table 3, Phelps and Hair (1974).

[4] Less than 2.5 million cubic feet.

[5] Preliminary estimates.

Sources: Based on data published by the U.S. Departments of Commerce and Agriculture.

TABLE 3.—*Production, imports, exports, and apparent domestic consumption of hardwood lumber products, by major product, 1950-73*[1]

(Million cubic feet, roundwood equivalent)

Year	All products		Industrial roundwood used for—																			
			Total				Lumber				Plywood and veneer				Pulp products					Logs		
	Domestic production	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports	Exports	Apparent consumption	Domestic production	Imports[2]	Exports[2]	Apparent consumption	Miscellaneous products[3]—apparent consumption	Imports	Exports	Fuelwood—apparent consumption
1950	3,645	3,740	1,915	125	30	2,010	1,130	45	15	1,155	160	5	(4)	165	215	55	5	260	410	20	5	1,730
1951	3,750	3,850	2,050	140	35	2,150	1,180	40	20	1,200	195	10	(4)	200	280	65	10	335	390	25	5	1,700
1952	3,470	3,540	1,935	115	40	2,010	1,105	35	25	1,115	185	10	(4)	195	270	60	10	315	370	15	5	1,530
1953	3,425	3,520	1,950	130	35	2,045	1,100	35	20	1,115	180	15	(4)	195	315	55	10	360	355	20	5	1,475
1954	3,365	3,450	1,945	130	50	2,030	1,080	30	20	1,095	165	30	(4)	190	350	55	20	380	345	15	5	1,420
1955	3,445	3,535	2,085	155	65	2,175	1,160	40	30	1,170	190	40	(4)	225	405	55	30	430	330	20	5	1,360
1956	3,485	3,595	2,185	175	60	2,295	1,220	40	30	1,230	190	45	(4)	235	455	70	25	500	310	25	5	1,300
1957	3,055	3,150	1,820	165	70	1,915	890	40	30	895	165	45	(4)	210	465	60	30	495	295	15	5	1,235
1958	2,975	3,070	1,800	155	65	1,895	920	35	25	925	155	50	(4)	205	435	55	30	460	285	15	10	1,175
1959	3,120	3,245	2,010	200	70	2,135	1,020	50	25	1,040	160	75	(4)	240	555	60	35	580	265	15	5	1,110
1960	3,040	3,125	1,995	180	90	2,080	955	45	25	975	155	60	(4)	215	615	60	55	625	255	15	10	1,045
1961	2,920	2,985	1,935	165	95	2,000	910	35	25	925	150	60	(4)	210	625	60	60	620	240	10	10	985
1962	2,970	3,075	2,055	205	100	2,160	970	45	20	1,000	150	75	(4)	220	695	70	65	700	225	10	15	915
1963	3,085	3,180	2,230	205	110	2,325	1,095	45	20	1,120	145	80	(4)	225	735	70	75	730	245	10	15	855
1964	3,145	3,240	2,350	225	125	2,445	1,110	45	20	1,135	160	90	5	245	815	75	90	800	255	10	10	795
1965	3,165	3,280	2,430	240	125	2,545	1,140	50	20	1,170	160	100	(4)	255	855	80	90	850	260	10	15	735
1966	3,200	3,340	2,525	275	140	2,665	1,180	65	25	1,220	135	110	(4)	240	945	90	100	935	255	10	15	675
1967	3,035	3,120	2,415	235	150	2,500	1,135	50	25	1,160	130	105	(4)	235	905	70	105	870	230	10	20	620
1968	2,970	3,115	2,410	310	160	2,555	1,095	55	15	1,130	135	160	5	295	940	85	125	900	220	10	20	560
1969	3,025	3,220	2,530	370	175	2,725	1,140	70	20	1,190	130	175	5	300	1,045	120	140	1,025	205	10	15	495
1970	2,905	3,030	2,470	335	205	2,595	1,090	50	20	1,120	125	165	5	280	1,050	110	170	990	195	5	15	435
1971[5]	2,830	3,020	2,430	380	190	2,620	1,060	55	25	1,090	130	205	5	335	1,030	115	150	995	195	5	10	400
1972[5]	2,905	3,130	2,520	445	220	2,745	1,040	70	40	1,065	145	225	5	400	1,105	115	155	1,060	215	5	20	385
1973[5]	3,065	3,275	2,665	420	205	2,875	1,035	85	35	1,080	145	210	5	350	1,225	120	135	1,205	230	5	30	400

[1] Columns may not add to totals because of rounding.

[2] Includes pulpwood and the pulpwood equivalent of wood pulp, paper and board.

[3] Includes cooperage logs, poles and piling, fenceposts, hewn ties, round mine timbers, box bolts, excelsior bolts, chemical wood, shingle bolts, and miscellaneous items.

Source: Table 4, Phelps and Hair (1974).

[4] Less than 2.5 million cubic feet.

[5] Preliminary estimates.

Sources: Based on data published by the U.S. Departments of Commerce and Agriculture.

Year	Imports	Exports	Deficit
	- - - -	*Million dollars*	- - - - -
1961	1,636.2	649.7	986.5
1962	1,763.7	655.2	1,108.5
1963	1,715.4	738.7	976.7
1964	1,790.0	866.6	923.4
1965	1,958.4	917.2	1,041.2
1966	2,163.6	1,024.3	1,139.3
1967	2,091.5	1,150.9	940.6
1968	2,427.1	1,362.2	1,064.9
1969	2,714.1	1,508.3	1,205.8
1970	2,527.9	1,818.0	709.9
1971	2,921.2	1,692.5	1,228.7
1972	3,606.9	2,037.6	1,569.3
1973	4,426.6	3,007.7	1,418.9

Sources: Kaiser and Mills (1973) and Phelps and Hair (1974).

Over the past decade, the value of imports has remained concentrated in lumber, chiefly softwood, woodpulp, and paper and paperboard products, primarily newsprint (fig. 1). The dollar value of exports was concentrated in woodpulp and paper and paperboard products during the early 1960's (fig. 2). During the 1970's, export value of all forest products increased, the biggest gains being in logs and lumber. On a commodity basis, the United States is a net importer except for logs.

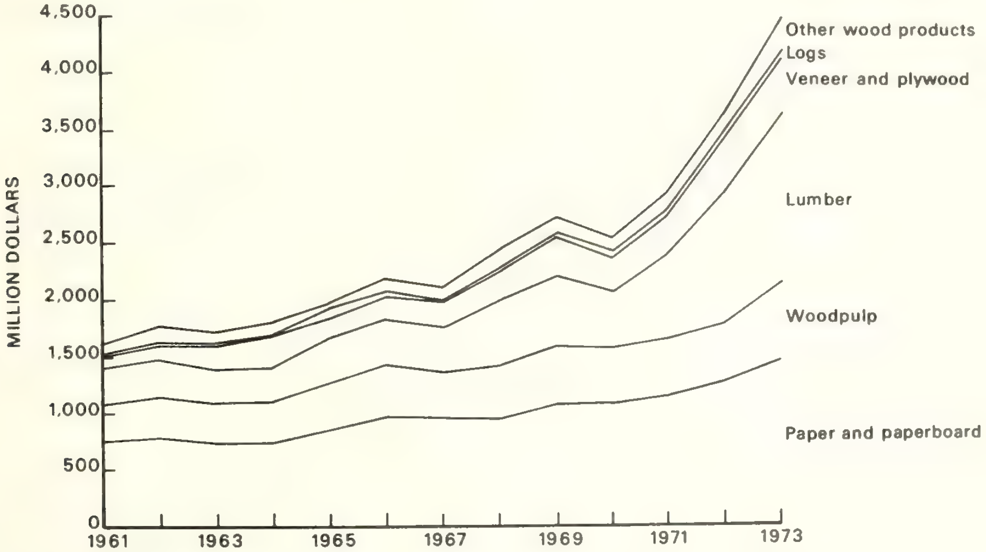

Figure 1.--Value of imports by product, 1961-73. "Other wood products" includes cork products and wooden packing boxes; "Logs" includes pulpwood and chips; and "Woodpulp" includes small amount of wastepaper. (Sources: Kaiser and Mills (1973) and Phelps and Hair (1974).)

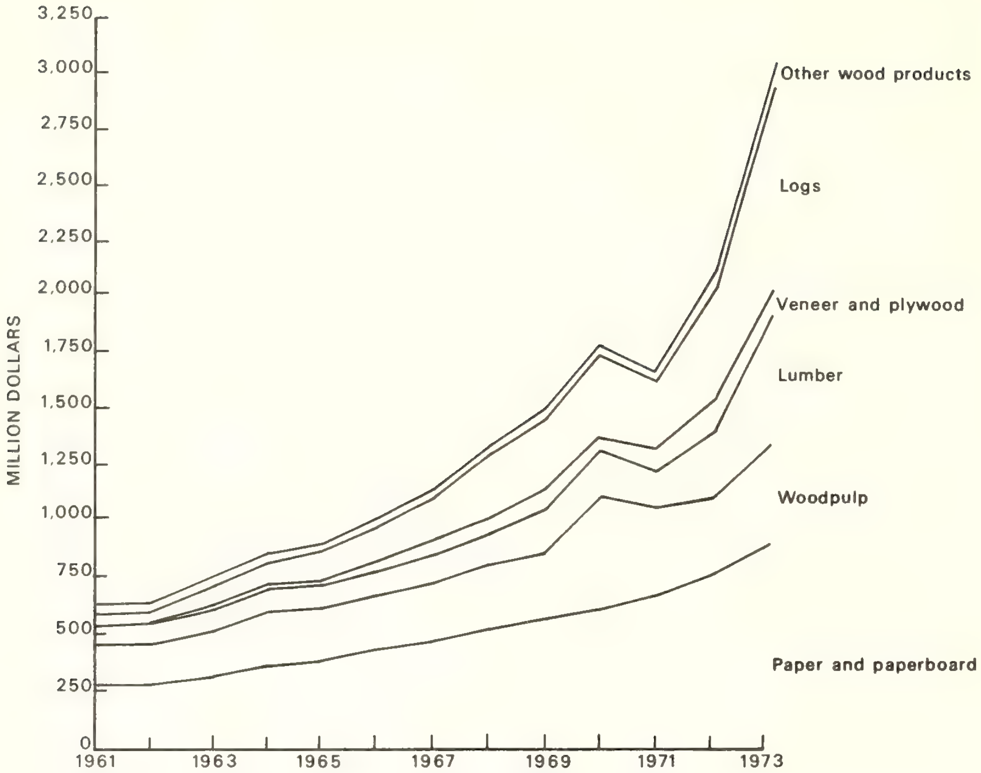

Figure 2.--Value of exports by product, 1961-73. "Other wood products" includes cork products and wooden packing boxes; "Logs" includes pulpwood and chips; and "Woodpulp" includes small amount of wastepaper. Sources: Kaiser and Mills (1973) and Phelps and Hair (1974).)

U. S. TRADE PATTERNS FOR MAJOR FOREST PRODUCTS

Foreign trade issues develop on an individual commodity basis. Much trade legislation deals with constraint or liberalization of imports. Restrictive policies often develop through political efforts of industries that consider themselves adversely affected by imports. In reaching a decision, Congress must weigh gains from import competition against the costs of disruption to domestic industry.

Imports of a specific commodity may also be limited to foster a competing domestic industry. For example, a country may tax automobile imports as an incentive to domestic manufacture of autos. Imports of a specific commodity may also be limited to regulate consumption; for example, a tariff on oil imports is expected to decrease consumption of oil and stimulate development of other sources of energy.

Imports of specific commodities may be limited to channel foreign exchange into other higher priority items. Thus, a country may heavily tax imported consumer goods to acquire foreign exchange for purchase of industrial goods.

Policies to boost exports of specific commodities generally seek to stimulate employment, achieve other domestic goals, or earn foreign exchange. In the United States, policies to limit or change the form of exports have come to the forefront in recent years because of the impact of exports on domestic interests. Temporary limits on agricultural exports were initiated because the export market caused domestic prices to rise. Proposals to limit softwood log and lumber exports imply the protection of the supply of domestic raw material--with benefits to final price and availability of products.

Trade policies for specific commodities may differ from the overall philosophy of a country toward international trade. Through the political system, members of an industry may be successful in restraining trade despite a philosophy of trade liberalism. Trade restraint in specific commodities necessarily complicates fulfillment of a liberal trade philosophy, especially in negotiations to reduce tariff or other barriers.

For trade policies in forest products, the linkage between a policy and domestic goals means that not only must the effect of a policy on net trade position or other international goals be assessed, but the effect on domestic goals must be included as part of the evaluation.

Since the forest products industries are only part of a general economic system, their trade policies should be evaluated within the context of the system. The effectiveness of different policies will vary according to domestic and international supply and demand conditions for each product and for substitute and complementary commodities. For example, the United States and the Union of Soviet Socialist Republics are the only countries which export significant quantities of softwood logs, but many countries export softwood lumber.

Issues which evolve from trade policies will depend in part on the countries involved. For example, U.S. policies to reduce forest products imports may be countered through reduction of market access for U.S. exports or through withholding of key materials.

The most important forest products imported during 1973 by leading country of origin were:

	Million dollars
Softwood lumber (total)	1,362.6
Canada	1,315.7
Woodpulp (total)	659.3
Canada	626.3
Newsprint	1,184.8
Canada	1,132.6
Hardwood veneers (total)	76.4
Canada	36.5
Philippines	19.6
Hardwood plywood (total)	388.3
South Korea	165.5
Taiwan	82.7
Japan	55.5
Philippines	40.2

Source: U.S. Bureau of the Census (1974b).

These commodities accounted for $3.7 billion out of total forest products imports of $4.4 billion. Clearly, if the United States wants to reduce imports, policies should be directed primarily to softwood lumber, newsprint, and woodpulp from Canada. Hardwood veneer and plywood imports amount to $464.7 million; policies to reduce these imports must be directed primarily to Asian countries.

The values of 1973 exports for selected commodities and countries of destination were:

	Million dollars
Softwood logs (total)	759.9
Japan	707.3
Softwood lumber (total)	506.0
Japan	114.7
Italy	70.9
Canada	67.6
West Germany	35.6
United Kingdom	19.3
Pulp chips (total)	85.7
Japan	84.6
Woodpulp (total)	420.3
Japan	79.8
United Kingdom	37.7
Italy	35.7
Canada	10.6
Paper and board (total):	918.5
Kraft container board liners, unbleached	235.8
West Germany	36.4
United Kingdom	30.8

Source: U.S. Bureau of the Census (1974a).

These commodities accounted for $2.7 billion out of total 1973 forest products exports of $3 billion. Japan was the major market for U.S. softwood logs and pulpwood chips, with purchases totaling $792 million.

Other exports went to many countries; and policies--especially for the more highly processed products--should be framed with this fact in mind. Exports of raw materials are concentrated in Japan.

FOREST PRODUCTS TRADE COMPARED WITH TOTAL U.S. IMPORTS AND EXPORTS

During the 1960's, forest products imports as a percentage of all commodity imports declined from about 11 to 6 percent; corresponding values for exports rose from 3 to about 4 percent (fig. 3).

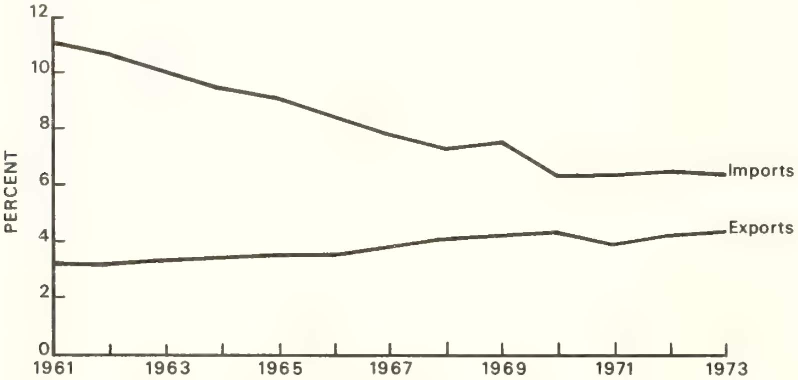

Figure 3.--Forest products trade as a percent of all U.S. merchandise trade, 1961-73. Percentages are based on forest products trade data from Kaiser and Mills (1973) and Phelps and Hair (1974); merchandise trade data are from Council of Economic Advisers (1974).

U.S. imports and exports of commodities are both dominated by manufactured goods (table 4). The United States is a net exporter of agricultural products and raw materials and a net importer of mineral fuels.

TABLE 4.—*Value of U.S. commodity imports and exports, 1973*

(Millions of dollars)

Commodity group	Imports	Exports
Food and live animals	7,986	11,931
Beverages and tobacco	1,213	1,008
Inedible crude materials except fuels[1]	4,988	8,384
Mineral fuels, lubricants, and related materials	8,101	1,671
Oils and fats, animal and vegetable	255	684
Chemicals	2,437	5,748
Manufactured goods, classified chiefly by material[2]	13,198	7,161
Machinery and transport equipment	20,970	27,842
Miscellaneous manufactured articles	8,184	3,951
Commodities and transactions not classified	1,790	1,844
Total	69,122	70,224

[1] Includes wood, lumber, and cork at an import value of $1,522 million and an export value of $1,303 million and pulps and wastepaper at an import value of $669 million and an export value of $487 million.

[2] Includes wood and cork products at an import value of $781 million and an export value of $299 million and paper, paperboard, and paperboard products at an import value of $1,457 million and an export value of $919 million.

Source: U.S. Bureau of the Census (1974a, 1974b).

When considering the relative effectiveness of different forest products policies, we should keep the perspective that policies to change the flow of other commodities may better achieve national and international goals.

Background for framing policies

THE TARIFF AND HOW IT AFFECTS TRADE

The term "tariff" can be applied to taxes on imports or exports. An ad valorem tariff taxes a fixed percentage of the value of the commodity; a specific tariff taxes a fixed sum of money per physical unit of the commodity. About one-half of the import duties applied by the United States are the ad valorem type, and one-half are the specific type. Export taxes are illegal in the United States.

Whether the buyer or the seller pays the tariff depends on the elasticities of supply and demand for the commodity. The more elastic the import demand schedule relative to the export supply schedule, the more the tariff will be borne by the exporting country. In general, the price to the exporter will decline and the price to the importer will increase if a tariff is applied to either imports or exports.

If imports are taxed, production expands in the industries producing substitutes. With full employment, this expansion can be accomplished only by drawing resources away from industries that presumably rank higher in the order of comparative advantage (otherwise, the resources would have been employed there in the first place, even before the tariff). The tariff forces a redistribution of income from other industries to substitute industries, and from the general public to the government. Because the import tariff raises the price to the consumer and protects the domestic producer, its effects are comparable to those of a combined tax and subsidy (Kreinin 1971).

A tax on exports decreases foreign demand for the previously exported item, decreases its domestic price, and decreases domestic production of the commodity and its substitutes, possibly to the benefit of unrelated commodities. It also forces a redistribution of income from taxed to nontaxed industries, possibly to consumers, and to the government. The net effect on income distribution to consumers depends on how much prices of other commodities are altered.

If an export tax is levied to relieve a domestic shortage of the commodity, domestic production may not decline. Export taxes, which are illegal in the United States, may be imposed by other governments to earn foreign exchange.

A tariff on imports may eliminate competition for a domestic industry and thereby increase monopoly control.

NONTARIFF BARRIERS TO TRADE

The March 1973 International Economic Report of the President (Council on International Economic Policy 1973) points out that 27 main categories of nontariff barriers (NTB) are reflected in 800 notifications made by countries participating in an inventory undertaken by the General Agreement on Tariffs and

Trade.[1] Examples include preferential government procurement practices, export and domestic subsidies, variable levies, quantitative restrictions, discriminatory taxes, customs valuation practices, and product standards that protect domestic suppliers.

Many nontariff barriers elude inventory. They arise mainly from differences in political-economic practices. For example, in some countries, local businesses agree among themselves not to import certain types of competing merchandise, sometimes with informal support from the government. In addition, government economic and social programs have included features that either obstruct imports directly or encourage exports by artificially lowering costs.

The precise effect of NTB is usually difficult to identify or measure, and some probably do not have a major impact on trade. There is general agreement, however, that many nontariff measures have been framed or administered in a manner which gives a significant competitive advantage to domestic producers and, in certain cases, even constitutes a virtual prohibition against import. Although most of the nontariff distortions operate to limit import competition, others are also widely used to encourage exports. Various types of subsidies and other incentives to export fall in this category.

Two of the more common NTB are the import quota and the export subsidy. Import quotas generally have as an objective protection of a domestic industry from competition. Some of the effects are: Consumption of the commodity declines as consumers switch to substitutes, production of substitutes expands, and government revenue increases if import licenses are auctioned (Kreinin 1971). The effects of the quota on total employment, income, balance of payments, and other criteria depend on what happens to the economic system in total.

The issue of export subsidies comes up often in trade in agricultural commodities. The effect is to channel resources from nonsubsidized industries into production of the subsidized commodity. Income is redistributed from the general public and other industries to the subsidized industry. Again, the net effect on domestic and international goals depends on the total impact on the economic system.

Within the U.S. forest products field, one of the major NTB's is the prohibition of log exports from Federal lands west of the 100th meridian. One effect of this policy is a shifting of foreign demand to private and State of Washington Department of Natural Resources lands. Income is redistributed from Federal to other lands, resources are maintained in firms dependent on Federal timber and possibly disrupted in domestic firms dependent on other lands for timber purchases. The net effect on domestic and international goals depends on the total economic system and not just on the individuals and firms directly affected by the policy.

The actions of cartels affect trade and are in effect NTB. Cartels composed of individual firms in an industry, possibly in different countries, are not new. Many industries composed of a limited number of companies have been pointed to as having the objectives of cartels, which may include price fixing, allocation of world markets among member firms to avoid competition, and control of technological research and development (Kreinin 1971). U.S. antitrust legislation has been used to bring charges against specific firms or groups of companies in domestic industries. Examples include members of the following industries: southern pine plywood, gypsum board, plumbing fixtures, computers, and telephone equipment.

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[1] See Kreinin (1971) for a discussion of the functions of the General Agreement on Tariffs and Trade.

International cartels include the International Air Transport Association and Organization of Petroleum Exporting Countries (OPEC).

The U.S. Domestic International Sales Corporation (DISC) program in effect subsidizes U.S. exports by postponing, under certain conditions, taxes on up to one-half of the income from exports.

All of these NTB's influence trading patterns through manipulation of factors which affect a country's comparative advantage. Each NTB has an effect on allocation of resources and distribution of income in a country's economy.

Trade unions or other multicountry trade organizations contain elements of cartels. Typically, members of the organization give other member nations preferential treatment in trade compared with nonmembers. The European Common Market is an example of this arrangement. This arrangement, in effect, gives member countries a comparative advantage in member countries' markets.

THE EFFECT OF SUPPLY AND DEMAND ELASTICITIES ON THE SUCCESS OF DIFFERENT TRADE POLICIES

In the U.S. economic system, trade patterns are generally changed through policies which change or maintain commodity prices. Exceptions to this philosophy are restrictions on exports of sensitive materials or restrictions on trade with specific countries. Relative domestic and international commodity prices guide producer and consumer decisions.

The effectiveness of different trade policies will depend in part on how producers and consumers respond to changes in relative prices. The elasticities of domestic and international supply and demand measure in part how producers and consumers respond to changes in price. Domestic or international goals related to price stability or aggregate commodity values are especially sensitive to the supply and demand elasticities for a commodity, its substitutes, and its complements.

The effect of a trade policy on total U.S. balance of payments depends on these elasticities. For example, a decrease in import volume would increase its total value if demand for the commodity were inelastic but would decrease value if demand were elastic. The decrease in value may be offset if substitute commodities are imported.

In the case of exports, an increase in volume would decrease total value if foreign demand were inelastic but would increase value if foreign demand were elastic. The effectiveness of U.S. export promotion policies will also depend on the elasticity of supply of similar products in competing supply regions.

These elasticities may change over time and over the range of prices and quantities in supply and demand schedules.

THE EFFECT OF FLOATING EXCHANGE RATES ON DIFFERENT TRADE POLICIES

Floating exchange rates can offset the intended effects of ad valorem and specific tariffs. As a country's currency is devalued relative to other countries', the price of its exports declines compared with that of other countries. Lower prices increase the competitive position of these products. If prices are lowered enough, the products become competitive in a domestic market despite tariffs intended to limit imports.

Inflation also tends to erode the intended effect of specific and ad valorem tariffs by reducing the value of the tariff relative to the total value of the product.

Quotas and other NTB's which are not related to price are relatively unaffected by floating exchange rates or other measures of relative advantage.

ADMINISTRATION OF BARRIERS TO TRADE

Tariffs are relatively easy to administer. The specific tariff of dollars per unit of product is less complicated than the ad valorem tariff which requires a valuation of the product. Subsidies for exports of a commodity also consumed domestically are more difficult to administer. Typically, domestic consumption is subsidized to the same extent as exports. Import quotas involve the problem of allocating the quotas among importers and over time. Other NTB's vary in need for administration.

National policies on imports and exports require approval of the U.S. Congress unless Congress has delegated the authority. Flexibility can therefore vary according to terms specified in each trade policy. Terms may be in response to short-term conditions, such as imposing a temporary prior import approval system for grains or other commodities and monitoring U.S. exports of these commodities, or to long-term policies designed to develop or maintain an industry for national security reasons.

From the standpoint of satisfying cyclical patterns of consumer demand, the nonprohibitory tariff has an advantage in that imports can respond to surges in demand despite the tariff. In the case of a quota, the response to surges in demand is the price of the commodity. A cyclical pattern of demand can be expected to result in spot shortages if response from imports is prohibited.

If, for some reason, the national policy is to balance net imports of a specific commodity, a mix of flexible import and export constraints and incentives would be necessary to pursue this goal over time. International and domestic markets change in response to changing supply and demand conditions. A policy to promote long-term development of an industry or other objectives should reconcile long-term with short-term needs of the country.

COMPARATIVE ADVANTAGE AS THE BASIS FOR TRADE

In a free market situation, nations trade because the exchange is mutually beneficial. Countries export goods or services for which they have a *comparative* advantage with other countries. Comparative advantage is defined as the relative costs of producing a unit of each good or service in each country. For example, assume that in the United States a thousand square feet of hardwood plywood costs $150 to produce and wheat $3 per bushel; assume corresponding costs for another country are $75 for plywood and $10 for wheat. In the United States, the ratio of the cost of plywood to wheat is 15 and in the other country 7.5. In this simplified example, the United States would produce only wheat and import all its plywood needs. The other country would produce only plywood and no wheat. For more than two countries and two commodities, trading patterns become correspondingly complex, but the principle of comparative advantage determines what is traded between any two countries. If the two countries have different currencies, an exchange rate between the two currencies will develop and permit the flow of trade between the two countries. The exact exchange rate depends on the supply and demand for the two goods in the two countries. Floating exchange rates would result in a rate which balances export and import values between the two countries.

Various multinational trading patterns develop. For example, a country with an inexpensive labor supply may import raw materials, process them, and sell finished products to a third country.

The ultimate trade flows among countries are limited by increasing costs of production and price-responsive demand in each country.

Trade also occurs or is curtailed for reasons other than those outlined under a free market situation. For reasons of national interest, a country may sell at reduced rates or give to other countries commodities or services which the countries would otherwise not be able to import. Or a country may limit or refuse to export or import specific commodities or services from other countries. Import or export patterns which are "forced" as against what would have occurred under the principle of comparative advantage may achieve the goals of national interest at a cost of trading opportunities forgone. In unique circumstances, a country may have such an overwhelming comparative advantage in a specific commodity and limited import needs that achievement of the national interest is compatible with domestic goals.

Trade policies to increase or decrease imports or exports operate to change the comparative advantage which would have existed without the policies. Presumably, these policies would be implemented to offset the impacts of trade where impact is measured in terms of conflicts with domestic policies or other reasons of national interest. A policy to decrease imports of forest products may decrease the total value of imports but would increase the cost of forest products to the consumer. Subsidy programs to make domestically produced goods cheaper to the consumer would offset to some extent the cost of forest products to users, but the total cost would be increased. To be balanced against this increased cost is the contribution of the policy toward domestic or other goals. A policy to increase exports of forest products may have the effect of increasing the total value of U.S. exports, but at the price of subsidies or other costs related to export promotion programs and possible dislocation of domestic industries dependent on the commodity being exported.

Policies to reduce imports or increase exports have the intention of improving the advantage of U.S. producers relative to other producers of similar products in competing regions. In the case of imports, if U.S. producers do not have the capability to respond, the effect of the policy is to raise prices of the commodity and increase the use of substitutes where the United States may or may not have a comparative advantage. In the case of exports, policies to increase exports may not be effective if U.S. producers do not have the capability to respond or if other countries counter the U.S. move by implementing their own export promotion policies. Potentials for decreased forest products imports and increased exports are discussed later.

In addition to the potential effect of forest products trade policies on other commodities and the issues raised by these impacts, the value of forest products exports or imports affects exchange rates between the U.S. dollar and other nations' currencies. The exchange rate determines the final terms of payments to be made for all imported or exported items. Fluctuations in this rate due to changes in the value of imported and exported goods and services have an impact on the stability of domestic operations and affect the feasibility of implementation of all international trade policies.

Exchange rates are based on the relative supply and demand for each country's currency. Demand for a currency reflects the current comparative advantage of each country and a speculative element based on expectations of the future strength of each currency relative to that of other countries. For example, if future devaluation of a currency is expected, this decreases the current demand for that currency. Domestic policies enter into this speculation through evaluation of the future stability of a country's comparative advantage. Domestic problems such as inflation tend to be viewed as indicators of future devaluation of a country's currency. Forest products trade policies which are not consistent with programs to deal with domestic problems such as inflation may work against the overall goals of the trade policy. For example, export promotion programs for a commodity at a time when the price of commodity is increasing rapidly in the domestic market may be counterproductive for exchange rate goals.

THE ROLE OF COMMODITIES IN THE BALANCE OF PAYMENTS ISSUE

The balance of payments always balances. Balance of payments transactions are tabulated with a double-entry system: each transaction has debit and credit aspects of equal size. Table 5 shows the different categories under which debits and credits are tabulated. An excess of debits or credits in one or more of these categories must be matched by an equal excess of credits (or debits) in the remaining ones.

The "balance of payments" generally refers to the surplus or deficit position of the total for the basic balance. All the items in the current account and long-term capital category are viewed as indicators of the overall strength of an economy. Before implementation of floating exchange rates in 1973, chronic deficits in this category were viewed as a problem in maintenance of fixed exchange rates. Chronic deficits precipitated crises which were generally followed by devaluation of the

TABLE 5.—*U.S. balance of payments summary by area*[1]

Billion US $

	Global		European Community		Japan		Canada		Other Developed [2]		Developing Countries		Communist Countries		International Organization and Unallocated [3]	
	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973	1972	1973
Exports	48.8	69.9	11.8	16.7	5.0	8.4	12.6	15.4	4.6	6.7	13.9	20.0	0.9	2.7	......	....
Imports	-55.7	-69.1	-12.6	-15.4	-9.1	-9.7	-14.4	-17.2	-4.4	-5.8	-14.8	-20.4	-0.4	-0.6	......	....
Net Trade	-6.9	0.8	-0.8	1.3	-4.1	-1.3	-1.8	-1.8	0.2	0.9	-0.9	-0.4	0.5	2.1	......	....
Military Sales	1.2	2.2	0.3	0.4	*	*	*	0.1	0.2	0.4	0.6	1.3	......	......	......	....
Military Expenditures	-4.7	-4.6	-1.9	-2.2	-0.8	-0.8	-0.2	-0.2	-0.3	-0.3	-1.5	-1.1	......	......	......	....
Net Military	-3.5	-2.4	-1.6	-1.8	-0.7	-0.8	-0.2	-0.1	-0.1	0.1	-0.9	0.2	......	......	......	....
Investment Income Receipts	14.0	18.8	2.8	4.0	0.6	0.8	2.4	2.9	1.3	1.8	6.3	8.8	*	*	0.5	0.5
Investment Income Payments	-6.1	-8.8	-2.8	-4.2	-0.9	-1.1	-0.7	-0.9	-1.0	1.8	-0.4	-0.6	*	*	-0.2	-0.2
Net Investment Income	7.9	10.0	*	-0.2	-0.3	-0.3	1.7	2.0	0.3	*	5.9	8.2	*	*	0.3	0.3
Travel Income	3.4	4.2	0.5	0.7	0.2	0.4	1.0	1.1	0.3	0.4	1.4	1.6	*	*	*	*
Travel Expenditures	-6.4	-7.0	-1.8	-2.1	-0.2	-0.2	-1.0	-1.1	-1.1	-1.1	-2.2	-2.3	*	-0.1	*	-0.1
Net Travel	-3.0	-2.8	-1.3	-1.4	*	0.2	*	*	-0.8	-0.7	0.8	-0.7	*	-0.1	*	-0.1
Other Services Net	0.5	0.9	0.1	0.1	0.3	0.5	*	-0.2	0.1	0.2	0.4	0.6	*	*	-0.2	-0.3
BALANCE ON GOODS AND SERVICES	-4.6	6.5	-3.6	-2.0	-4.8	-1.7	-0.3	-0.1	-0.3	0.5	3.9	7.9	0.5	2.0	0.1	-0.1
Remittances	-1.6	-1.6	*	-0.1	*	*	-0.1	-0.1	-0.3	-0.3	-1.1	-1.1	*	*	*	*
US Government Grants (excluding military)	-2.2	-2.2	*	*	*	*	*	*	*	*	1.9	-2.0	*	*	-0.3	-0.2
BALANCE ON CURRENT ACCOUNT	-8.4	2.7	-3.7	-2.1	-4.8	-1.7	-0.4	-0.2	-0.6	0.2	0.9	4.8	0.5	2.0	-0.2	-0.3
US Government Capital Flows	-1.3	-1.6	*	*	*	0.6	*	*	-0.1	-0.1	-1.1	-1.6	-0.1	-0.4	-0.1	-0.1
US Direct Investment Abroad	-3.4	-4.0	-1.0	-2.1	-0.2	-0.1	-0.4	-0.3	-0.5	-0.5	-0.9	-0.7	*	*	-0.4	-0.3
Foreign Direct Investment in US	0.2	1.9	-0.1	0.8	*	0.2	0.1	0.1	0.1	0.2	*	0.6	*	*	*	*
Net Portfolio Investments	3.7	3.8	3.0	1.6	0.2	0.7	-0.7	-0.2	1.3	1.3	-0.2	*	*	*	0.2	0.4
Other Long Term Private Capital[4]	-0.7	-0.8	0.1	*	0.3	0.3	-0.2	-0.1	*	*	-1.1	-0.7	*	-0.3	*	*
Net Long Term Private Capital Flows	-0.2	0.9	2.0	0.3	0.3	1.1	-1.1	-0.5	1.0	1.0	-2.2	-0.8	*	-0.3	-0.1	0.1
BASIC BALANCE	-9.8	2.0	-1.7	-1.8	-4.3	*	-1.6	-0.6	0.3	1.1	-2.5	2.4	0.4	1.3	-0.4	-0.4
Allocations of SDRs	0.7															
Private Short Term Flows	-1.6	-6.0														
Errors and Omissions	-3.1															
NET LIQUIDITY BALANCE	-13.9	-4.0														
Liquid Private Capital	3.5	-1.0														
OFFICIAL SETTLEMENTS BALANCE	-10.3	-5.0														

***Less than $50,000,000.**

[1] May not add due to rounding. 1973 figures estimated (based on three-quarters of a year data).

[2] Australia, New Zealand, South Africa and other Western Europe.

[3] Includes transactions with shipping companies operating under the flags of Honduras, Liberia and Panama.

[4] Includes changes in claims on or liabilities to private foreigners reported by U.S. banks and changes in loans or other long term claims or liabilities of U.S. nonbanking concerns to foreigners other than foreign affiliates.

Source: Table 19, Council on International Economic Policy (1974).

currency of the country with the deficit problem. Floating exchange rates automatically devalue or revalue currency according to the deficit or surplus of a country's balance of payments.

Devaluation of a currency cheapens that country's exports and raises the cost for imports; this should lead to export expansion and import curtailment needed for a balance in the basic balance category. For any time period, if the basic balance shows a surplus or deficit, the balancing items in the double entry accounting system are short-term claims and liabilities and errors and unrecorded transactions. Allocations of Special Drawing Rights are not a factor in the balance of payments since the move to floating exchange rates.

The major changes in our balance of payments have been attributable to swings in merchandise trade. As shown in figure 4, the merchandise trade balance went from a $6.8 billion surplus in 1964 to a deficit of about that much in 1972. Merchandise trade went from a deficit in 1972 to a surplus in 1973 due primarily to devaluation of the dollar effected through floating exchange rates initiated during 1973. Figure 5 shows the magnitude of major currency movements during 1973. Changes in relative currency values have an effect on trade in specific commodities only after a lag of several months to several years. The lag time depends on conditions such as availability of capacity to produce the commodity.

Floating exchange rates cause the basic balance in the balance of payments accounts to be self-correcting; a move to a deficit position will be countered by a devaluation; a move to a surplus position will be countered by an upward valuation of the country's currency. However, fluctuations in

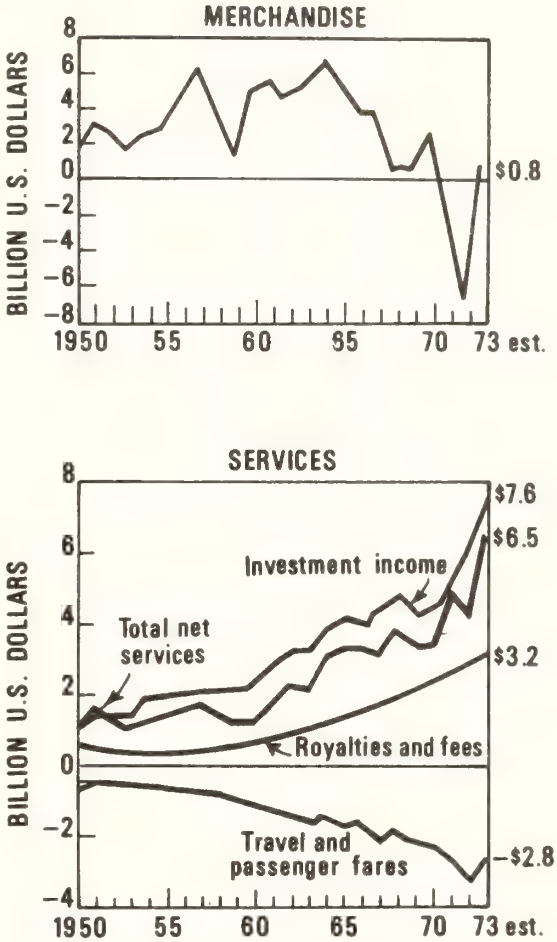

Figure 4.--U.S. basic balance trends. Source: Figure 21, Council on International Economic Policy (1974).

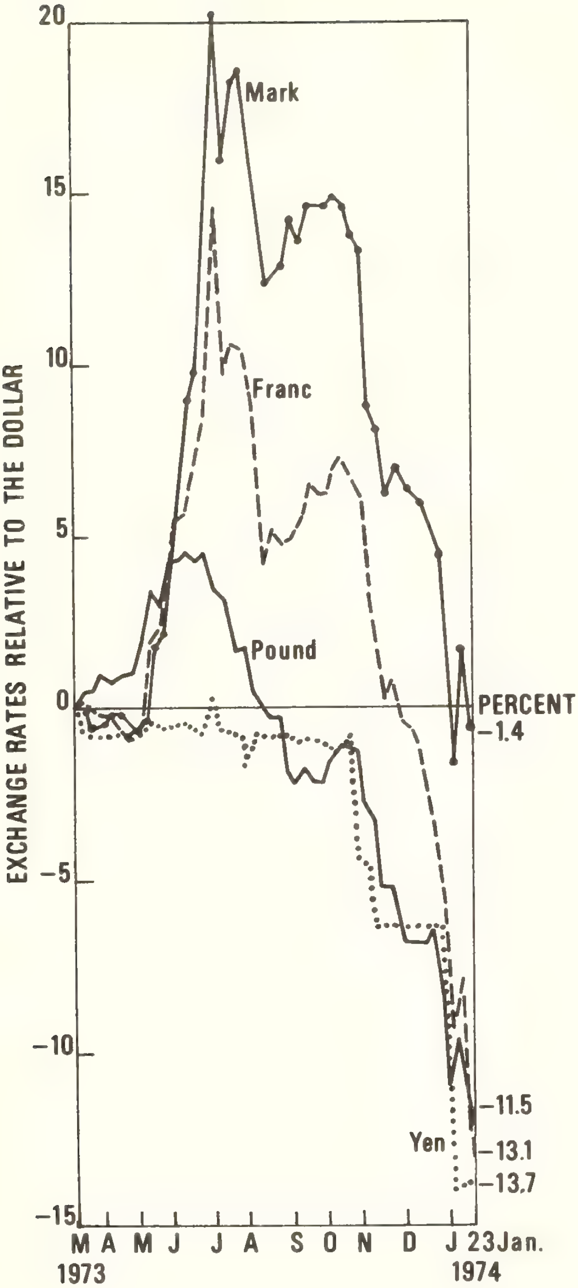

Figure 5.--Currency trends since March 19, 1974. Source: Figure 18, Council on International Economic Policy (1974).

currency cause fluctuations in the supply of imported or exported raw materials and finished products. These fluctuations may not be compatible with employment, price and other domestic policies, or other goals of foreign trade. International trade policy questions are now developing and will probably continue to be based on the impact of changes in exchange rates on domestic policies rather than solely on policies to correct balance of payments problems.

There are differing philosophies on the need for policies to affect the U.S. balance of payments under a floating exchange rate system (Friedman and Roosa 1967).

One argument is that we should pursue domestic policies to the fullest extent possible and let balance of payments and other international trade aspects of the economy take care of themselves through the floating exchange rate system. Any adverse effects of our trading pattern on the economies of other countries or the U.S. economy will be taken care of by the supply and demand for each country's currency. Proponents of this argument point to the role of trade in the U.S. economy as being of minor consequence compared with total production. For example, in 1972, exports amounted to less than 15 percent of total U.S. production of goods. Pursuit of international policies independent of their effects on domestic programs, according to this argument, is similar to the "tail wagging the dog."

Countering this argument is the rationale that the United States is becoming increasingly dependent on world trade to maintain the U.S. standard of living. Instability in exchange rates translates into instability in trade which is disruptive to the U.S. economy. Domestic policies needed to insure stable growth in trade are essential for increased living standards, not only in the

United States but in the rest of the world.

Both arguments stress the achievement of domestic goals. Neither argument necessarily implies that "more exports are better." Stability in exchange rates, and therefore trade, may require domestic policies which are incompatible with domestic goals. Whether either argument should be used as the basis for trade policies depends on the policymaker's weighing of the trade offs among international and domestic goals.

BALANCE IN SPECIFIC COMMODITIES

The principle of comparative advantage would only by coincidence lead to equality of imports and exports for a specific commodity. On the contrary, the basis for trade should lead to specialization for at least some commodities. Policies to decrease or increase imports or exports develop because of the current or potential impact of trade on domestic industries or goals and not because of an objective of balancing trade in the commodity.

The need for import or export policies to stabilize trade or exchange rates should be evaluated within the framework of the country's total trade position and not on a commodity-by-commodity basis: Surpluses in some commodities are necessary to offset deficits in other commodities. The feasibility of initiating policies to increase exports of one commodity to decrease imports of another depends on the trade offs involved between domestic and international goals.

The basis for trade may also lead to U.S. imbalances in trade with individual countries but an overall advantage. The March 1973 International Economic Report of the President (Council on International Economic Policy 1973) states that: "Our primary objective is to achieve an overall payments balance, not a balance in any particular account or with any individual country or group of countries."

Exchange rate fluctuations of the U.S. dollar are based on the country's total trade position and not the U.S. trade position with each individual country or with each individual commodity.

THE BALANCE OF PAYMENTS ISSUE WITHIN THE PERSPECTIVE OF THE GOALS OF TRADE

Specific trade policies for the United States depend on the issues which have developed for specific commodities and the overall foreign policy between the United States and each trading partner. The apparent overall philosophy which guides U.S. trade policy negotiations is represented by this statement in the March 1973 International Economic Report of the President (Council on International Economic Policy 1973):

> Our basic objectives in multilateral trade negotiations are:
> 1. to build on and expand international economic efficiency by removing obstacles to the freer play of market forces in determining the level and pattern of world trade, while at the same time developing agreed rules under which safeguards could be invoked when abrupt increases in competition threaten to disrupt national markets, and
> 2. to obtain changes in the system under which nations conduct their trade relations to ensure that the rules are fair and apply equitably to all parties.

These objectives aim at fostering economic growth and employment in the United States, liberalizing trade barriers on a basis that secures substantially equivalent competitive opportunities for U.S. commerce in foreign markets, establishing equity in international trading relationships (including reform of trade rules), providing adequate procedures to safeguard U.S. industry and labor from injurious or unfair import competition, and assisting industries, firms and workers to adjust to trade changes. This policy implies that the United States reserves the right to initiate other policies as a safeguard to counter the effect of exchange rate variations if they undermine negotiated concessions. An example of this philosophy is the temporary restraint on grain exports.

The Trade Act of 1974 (H.R. 10710) sets the terms of U.S. trade negotiations for years to come. These terms are generally consistent with the objectives stated in the International Economic Report of the President (Council on International Economic Policy 1973).

The balance of payments issue within the perspective of these goals is not the only basis for development of trade policies. Rather than a balance between imports and exports, these goals imply policies to expand trade, both imports and exports, consistent with domestic stability. The apparent rationale for the goal of expansion of trade is that trade is mutually beneficial to all participants and ultimately raises the standard of living in participating countries.

The Trade Act of 1974 gives the President authority to negotiate balance of payments problems, but the need for implementation of policies under this authority is to be based on the overall trade balance and not on the balance of any one commodity.

CARTELS

The apparent success of OPEC in the area of crude oil has increased interest in the possibility of cartels which might regulate forest products imports into the United States. Interest is centered not on industrial cartels but on multinational cartels among governments.

Bergsten (1974) points out conditions for a successful cartel:

1. Demand for the product must be relatively insensitive to price changes.
2. Supply of the product must be relatively insensitive to price changes.
3. Potential colluding countries must be able to get along with each other.

These conditions are necessary for formation of a cartel but appear to be incomplete for successful sustained operation of a cartel. The following conditions would facilitate successful cartel operation:

1. Demand for the commodity is growing and not subject to sharp cyclical swings in price and volume. If this condition does not exist, the cartel faces the problems of reconciling production with demand so as to maintain price. In a cyclical downturn situation, the production cutbacks necessary to maintain price may be intolerable to the domestic economies of some cartel members.

2. Several distinct markets for the cartel's products have been developed. This condition enables the cartel to bargain independently with each market. If this condition is not present, the cartel must negotiate terms with just one country and the lack of competing consumers reduces the leverage of the cartel in these negotiations.

3. The commodity is a necessity to maintain the life style or standard of living of consuming countries. Petroleum and other raw materials are basic to an industrial society. If these raw materials are suddenly not available, the society must change or accommodate the cartel. If this condition does not exist, consuming countries have the option of not negotiating with the cartel.

4. Cartel members must not be wholly dependent on consuming countries for maintenance and development of members' economies. If consuming countries can retaliate against the cartel by withholding other commodities or refusing to purchase other commodities essential to the cartel members, the position of the cartel becomes tenuous.

Multinational cartels are not an issue with U.S. softwood forest products imports. Issues related to volume or price of these imports depend on bilateral relations between Canada and the United States. Although the United States is dependent on Canadian softwood imports, Canadian producers are dependent on the U.S. market. In 1972, the United States purchased 87 percent of Canada's exports of softwood lumber, 79 percent of Canadian newsprint exports, and 57 percent of Canadian woodpulp exports (Food and Agriculture Organization of the United Nations 1974). Canadian producers can be expected to try to get the highest prices possible, but the interdependence of U.S. and Canadian interests works against exploitive pricing policies. In 1973, Canada accounted for 21 percent of all U.S. exports and 26 percent of U.S. imports. The United States purchases about two-thirds of Canada's total exports (U.S. Bureau of the Census 1974a, 1974b).

The case for hardwood veneer and plywood is not so clear. In 1972, the United States purchased 89 percent of the hardwood plywood exported from South Korea, 75 percent of exports from Taiwan, and 83 percent of exports from the Philippines (Food and Agriculture Organization of the United Nations 1974). The long-standing relationship between the United States and these three countries and the dominance of the U.S. market are arguments against the formation of cartels. The United States takes 47 percent of South Korea's total exports and 42 percent of exports from the Philippines. U.S. imports from Taiwan of $1.8 billion in 1973 amounted to over one-half of total exports from the country. South Korea and Taiwan do not have significant domestic sources of hardwood logs (Hutchison et al. 1974). Uncertainty about raw material supplies strengthens the argument against cartel formation.

Indonesia, Malaysia, and the Philippines are the main sources of hardwood logs in the southeast Asia area as shown in table 6.

TABLE 6.—*Hardwood log imports and exports by country of origin and country of destination for selected countries, 1972*

(In thousand cubic meters)

Country of destination	Country of origin				
	Indonesia	Malaysia	Philippines	Others	Total imports
Taiwan	1,240	906	739	0	2,885
Japan	8,506	6,828	5,146	857	21,337
South Korea	1,855	1,611	368	11	3,845
Singapore	0	1,378	10	11	1,399
Hong Kong	65	259	0	16	340

Source: Food and Agriculture Organization of the United Nations (1974).

Future developments are more likely to be in the form of increased log processing in the country where the logs originate than in cartels in hardwood plywood. This would change the national origin of hardwood plywood exports but does not necessarily imply a cartel. Economies of southeast Asian countries are increasingly becoming intertwined with the Japanese economy. Hardwood log cartels would face the problem of dependence on the Japanese economy.

Hardwood plywood is produced in the Asian countries because of cost. Significant increases in price would increase substitution of plastic overlays and hardwoods from African and South American sources and increase the use of low quality hardwoods in the United States.

DIFFERENT PHILOSOPHIES ON RETENTION OF A RESERVE OF TIMBER INVENTORY

There are differing philosophies on the need for retention of a reserve of timber for reasons of national interest. This is to be expected because each individual has a differing view of how the national interest should be defined.

The argument for a reserve of raw materials in case of war has lost proponents with the development of superpower foreign policy. The rationale is that full-scale war between the United States and potential adversaries would be of short duration. Under these circumstances, several years--or in the case of timber, several decades--of raw material in reserve are not necessary.

In the case of nonrenewable resources, a philosophy has developed for curtailing domestic production and importing as much as we can. The rationale is that if we had followed this policy in oil, Middle East rather than U.S. oil reserves would now be depleted. The case for renewable resources is not so clear. Timber is a renewable resource, given enough time. Japan is currently following this policy in timber production. Domestic timber production has been curtailed and reliance placed on imports to build up domestic inventories.

If a country is in a surplus position in timber inventory, this philosophy can be followed only at the expense of current consumption and lower prices. An attitude of future long-term world shortages of the commodity is an integral part of this philosophy. Implementation of this policy depends on the ability of the country to withhold the commodity from the export market. The country must have export options and be willing to bear the cost of trade opportunities forgone.

Another view of the need for a reserve of timber is that timber represents capital. Timber capital should be managed as efficiently as other capital. Maintenance of an inventory of capital which might be used for other purposes involves unnecessary cost. Capital released in the form of timber helps to build a stronger economic base for the country. A stronger economic base helps to develop options to dependency on any one resource. Efficient management of timber capital does not imply liquidation of all inventories. If future shortages develop, the price of timber products will rise which will increase the cut from the remaining inventory and stimulate investment in forest management which will increase supplies. Rising wood prices will stimulate the move to a fiber-based forest industry and lessen the need for larger trees.

Either the philosophy of retaining a reserve of timber or the philosophy of efficient management can be followed depending on the Nation's goals and view of the future. A reserve of timber implies the willingness to forgo current consumption in favor of protection of future options.

Efficient management of capital implies the willingness to consume more now and accept the potential risks of future events.

BALANCE TRADE ON VOLUME OR VALUE?

Previous discussion has pointed out that trade in a specific commodity would only coincidentally result in a balance between imports and exports. Trade based on the principle of comparative advantage should result in surpluses in some commodities and deficits in others. However, if the Nation were to initiate policies to balance trade in forest products, the question of balance on volume or value must be considered.

Traditional forest management of public lands has concentrated on management of volume rather than of price or value. Management of volume is attractive because of wide fluctuations in price. These fluctuations would cause cyclic variations in management needs. Management of the balance of payments in terms of volume is not feasible. The dollar is the common denominator which permits the aggregation of the values of different commodities so that the U.S. trade position relative to other countries can be assessed. Exchange rates are based on the monetary value of imports compared with exports. From a standpoint of trade, import or export policies are based on value, not volume.

On the other hand, the feasibility of import or export policies must be related to volume. Volume determines the extent of resources necessary to change production levels of the commodity and the availability of the commodity to meet producer and consumer needs. In the case of forest products, policies to increase exports must be consistent with the ability of timber growers and processors to increase production. Policies to decrease imports must be related to the impact of these policies on domestic availability of the commodity.

In 1973, forest products imports amounted to $4.4 billion and exports $3 billion, a deficit of $1.4 billion. If the Nation had a policy to balance imports and exports, at what level should imports balance exports? Should exports be increased by $1.4 billion, imports be decreased by $1.4 billion, should we not trade forest products at all, or what? There is no obvious answer. Rationales can be developed for increasing or decreasing either imports or exports of a specific commodity. These rationales would include consideration of both domestic and international goals. There is no reasonable basis, either in theory or in existing trade policies, for achieving a balance of trade in a specific commodity.

The goal of increasing exports and decreasing imports where possible is feasible only if developed within the context of domestic and international needs. These needs may conflict. Fulfillment of this goal would only coincidentally result in a balance between imports and exports.

TRADE OFFS BETWEEN DOMESTIC AND INTERNATIONAL GOALS: THE EXAMPLE OF SOFTWOOD LOG EXPORTS

Trade policies either implicitly or explicitly weigh trade offs among domestic interests and international goals. Issues develop about the weights to be given various interests in considering different policies. The softwood log export issue is described here as an example of the trade offs which can be involved in framing policy options. No attempt is made to weigh pro and con arguments. In the U.S. system, these weights are determined through the political process.

The continuing debate over softwood log exports is centered on exports from Washington and Oregon to Japan. Exports from these two States amount to over 90 percent of total west coast shipments. Over the past

5 years, export volume from the west coast has generally ranged between 2 billion and 2.5 billion board feet. Japan generally takes over 90 percent of annual west coast softwood log exports. The United States also exports softwood logs to Canada, South Korea, and other countries; but this trade is peripheral to the main issue.

The issue has developed since 1962. Over the period 1962-70, export volume from Washington and Oregon increased from about 300 million to 2.2 billion board feet (Ruderman 1975). Increased trade with the Soviet Union, political factors, and leveling of demand in Japan were major factors in the leveling off of volume in the 1970's.

The export market was initially looked upon favorably as an outlet for timber from salvage operations in the wake of the 1962 Columbus Day storm. The increasing volume of the mid-1960's caused questions about the impact of log exports on the timber-based economy of the Pacific Northwest. The debate on these questions led in 1968 to the Morse Amendment which limited log exports from federal lands to 350 million board feet. After a relative lull in the log export debate after passage of the Morse Amendment, the issue again came to the forefront in 1972 and 1973 when unprecedented U.S. and Japanese housing demands forced log prices and U.S. lumber and plywood prices to record highs.

Prior to expiration of the Morse Amendment in 1973, log exports from Federal lands west of the 100th meridian were banned by riders to appropriation bills of the affected agencies. The ban, in effect for fiscal year 1974, was renewed for fiscal year 1975. Lands owned by the State of Washington account for about 25 percent of total log exports from the two States. Most of the remaining 75 percent comes from private lands (Bergvall and Ormrod 1974, Schuldt and Howard 1974). Log exports from State of Oregon lands were banned in the 1960's.

The issue continues to center on the impact of an export market on domestic raw material markets. Gains from the trade have accrued primarily to the owners of stumpage and individuals and firms involved in logging, transporting, and processing logs in the export market. Their representatives have argued in favor of log exports.

On the other side of the issue, firms and individuals which purchase stumpage in competition with exporters have argued against log exports. In addition, representatives of conservation- and preservation-minded groups have raised questions about the impact of log exports on timber harvesting. Representatives of the U.S. construction industry have opposed both log and softwood lumber exports because of their possible impact on final product prices.

A resource-short Japan relies on wood imports for about one-half its domestic needs. Softwood timber products are preferred for construction in Japan, and most softwood log imports are used for this purpose. The three areas of the world which have substantial inventories of softwood timber are the U.S. west coast, British Columbia, and the Soviet Union. British Columbia prohibits log exports unless surplus to needs of domestic industries. Japan imports lumber from British Columbia and logs from the other two areas. From the Japanese viewpoint, the increasing worldwide debate over controls of basic raw materials raises many questions about the ability of the country to provide for the needs of its people. Preferences for logs rather than processed products are based in part on maintaining a long-standing small-business timber processing industry in Japan and the unique sizes required by the Japanese housing industry.

Timber processors in the Pacific Northwest are geared to the sizes of lumber and plywood consumed in U.S. markets. There has been little organized effort to develop the Japanese market. On the other hand, the Japanese have done little to foster development of processing capacity in the United states geared to Japan's needs.

Controls on exports of softwood logs and other raw materials from the United States to Japan have become intertwined with the foreign policy-based relations which determine bilateral trade in all commodities.

Proposed solutions to the conflicts among interests generally contain one of two elements: export more processed products instead of logs or increase timber sales from National Forest lands.

The Japanese are moving toward the use of the so-called "2X4" housing construction method which uses lumber with dimensions similar to the lumber consumed in the United States. Whether this construction method means more imports of softwood lumber is not clear. Maintenance of a politically sensitive domestic processing industry geared to the "2X4" materials is another possibility. If the Japanese would purchase these materials from existing U.S. sawmills, many of the arguments against forest products exports would subside. However, the issue of the impact of exports of construction materials on U.S. housing costs would remain.

National Forest timber output could be increased with the funding necessary to intensify management. Whether this option would provide enough timber for both the export and domestic markets and thereby alleviate conflicts among interests is uncertain. An increase in National Forest output may be necessary to sustain existing capacity in some areas of the Pacific Northwest. In other areas, increased output might be the basis for expansion of domestic capacity to process timber for the domestic market. In either case, questions about the impact of log exports would still remain.

The log export issue grew from a regional controversy centered in the Pacific Northwest to become in part the basis of multinational trade policies. Proposed solutions involve trade offs among Japanese and United States domestic interests and international goals.

Potential forest products trade policies within the apparent U.S. trade philosophy

Any potential forest products trade policy should be measured against the terms of the Trade Act of 1974 (H.R. 10710); policies not consistent with the act would probably find little support in Congress.

The overall negotiating objective under the act is to obtain more open and equitable market access for U.S. exports of goods and services and to harmonize, reduce, and eliminate barriers to international trade.

The act also makes it a principal U.S. negotiating objective to obtain competitive opportunities for U.S. exports to developed countries with respect to appropriate sectors on manufacturing and the agricultural sector. These should be equivalent to the competitive opportunities afforded similar products in U.S. markets. U.S. negotiators are directed to obtain, to the extent consistent with maximum overall economic benefits to the United States, equivalent competitive opportunities. An example would be bargaining U.S. import concessions within one sector of manufacturing for foreign concessions resulting in equivalent market opportunities for U.S. exporters in that sector.

Private advisory committees will advise the negotiators on how goals in the negotiations can best be accomplished. If the special representative for trade negotiations fails to accept their recommendations, he is required to inform the advisory committees of this decision; and the President's annual report to the Congress on the trade agreements program must include an explanation by the special representative for rejecting committee advice. Private sector advisory committees, established by the act, will issue formal reports at the conclusion of agreements affecting their sectors, evaluating the equity and mutuality of the agreements within their sectors. The Congress, therefore, will be better able to judge whether this negotiation achieved mutual benefits for the commerce of the United States.

A further negotiating objective is to obtain international safeguard procedures designed to permit the use of temporary measures to ease the adjustment to change brought about by any change in policy.

The act establishes as a principal negotiating objective, the entering into of foreign trade agreements to assure the United States of fair and equitable access at reasonable prices of articles of commerce important to U.S. economic requirements, and for which the United States does not have, or cannot easily develop, the necessary productive capacity.

The act authorizes and encourages the President to enter into bilateral trade agreements where such agreements would better serve U.S. economic interests than agreements undertaken on a multilateral basis. In addition, the act provides that the President may enter into a trade agreement with Canada aimed at eliminating or moving to eliminate trade barriers between the two countries on a reciprocal basis.

Forest product trade policies which involve U.S. unilateral raising of trade barriers to forest products imports or exports and subsidies or other government intervention in the comparative advantage of U.S. exports would run counter to the philosophy implied by the Trade Act.

Potential forest products trade without a change in policy

The current and prospective U.S. timber resource situation is discussed in the "Timber Outlook" report (USDA Forest Service 1973).

Under the range of conditions considered in the report, the United States will continue to be a net importer of forest products in volume (table 7). Total exports would remain at 1.8 to 1.9 billion cubic feet from 1980 to 2000. Imports may rise from 2.4 billion cubic feet in 1970 to 4.6 billion in 2000. Potential increases in imports are mainly woodpulp, paper, and softwood lumber from Canada at higher U.S. prices than in 1970. Imports exceeded exports by 1 billion cubic feet in 1970. The maximum excess of imports over exports would be 2.8 billion cubic feet in 2000 with "rising relative prices"; net imports would then equal 15 percent of U.S. consumption of all forest products. The minimum excess of imports over exports would be 0.8 billion cubic feet in 1980.

This analysis indicates a continuing dollar deficit in U.S. forest products trade. At a minimum, the deficit would probably be $1 billion to $1.5 billion; and it might be several billion dollars. A deficit is neither good nor bad until weighed with options according to their effect on domestic and international goals.

The future potential for exports and imports of specific forest products has been discussed by Holland (1973) and the USDA Forest Service (1973).

TABLE 7.—*Summary of roundwood consumption, exports, imports, and production from U.S. forests, 1952, 1962, and 1970, with projections (medium level) under alternative price assumptions to 2000*

(Billion cubic feet, roundwood equivalent)

Item	1952	1962	1970	Projections								
				1970 relative prices			Rising relative prices[1]			Relative prices above 1970 averages[2]		
				1980	1990	2000	1980	1990	2000	1980	1990	2000
SOFTWOODS												
U.S. consumption	8.4	8.5	9.7	12.1	14.1	15.8	11.2	12.4	13.5	10.7	12.7	14.3
Exports	.2	.4	1.2	1.7	1.6	1.6	1.7	1.6	1.6	1.7	1.6	1.6
Imports	1.3	1.7	2.1	2.3	2.3	2.3	3.1	3.7	4.0	3.2	3.6	3.7
Production from U.S. forests[3]	7.3	7.2	8.8	11.5	13.4	15.1	9.8	10.3	11.1	9.2	10.7	12.2
HARDWOODS												
U.S. consumption	3.5	3.1	3.0	4.3	5.5	7.0	4.0	4.7	5.7	3.9	4.9	6.4
Exports	(4)	.1	.2	.2	.2	.2	.2	.2	.2	.2	.2	.2
Imports	.1	.2	.3	.4	.4	.4	.5	.5	.6	.6	.6	.6
Production from U.S. forests[3]	3.5	3.0	2.9	4.1	5.3	6.8	3.7	4.4	5.3	3.5	4.5	6.0
ALL SPECIES												
U.S. consumption	11.9	11.6	12.7	16.4	19.6	22.8	15.2	17.1	19.2	14.6	17.6	20.7
Exports	.2	.5	1.4	1.9	1.8	1.8	1.9	1.8	1.8	1.9	1.8	1.8
Imports	1.4	1.9	2.4	2.7	2.7	2.7	3.6	4.2	4.6	3.8	4.2	4.3
Production from U.S. forests[3]	10.8	10.2	11.7	15.6	18.7	21.9	13.5	14.7	16.4	12.7	15.2	18.2

[1] Relative prices rising from 1970 trend level as follows: lumber—1.5 percent per year; plywood, miscellaneous products, and fuelwood—1.0 percent per year; paper and board—0.5 percent per year.

[2] Relative prices of lumber and plywood—30 percent, miscellaneous products and fuelwood—15 percent, and paper and board—10 percent above the 1970 averages.

Source: Table 152, USDA Forest Service (1973).

[3] The data for 1952, 1962, and 1970 are estimates of actual harvests and are not directly comparable with the trend level estimates of supply shown in Chapter II.

[4] Less than 50 million cubic feet.

Note: Data may not add to totals because of rounding.

Sources: 1952-70—Based on data published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

Policies to decrease imports or increase exports

Options for decreasing current and prospective imports of forest products are limited primarily to softwood lumber, newsprint, and woodpulp from Canada and to a lesser extent, hardwood veneer and plywood from Asia. Policies to decrease these imports include forcing a reduction of imports through restriction, improving the efficiency of domestic processing capacity relative to the efficiency of competing producers in other countries, and increasing domestic timber supplies to lower prices and reduce the incentive and need to import. The latter two policies have potential for increasing exports as well as reducing imports.

REDUCING IMPORTS THROUGH RESTRICTIONS

Imports from Canada in 1973 included $1,315.7 million of softwood lumber, $1,132.6 million of newsprint, and $626.3 million of woodpulp. The total came to $3,074.6 million out of aggregate U.S. forest products imports of $4.4 billion. Tariffs, duties, or quotas to significantly reduce the import value of any one of these commodities might bring retaliation. Total 1973 Canadian exports amounted to $25.2 billion. Exports of softwood lumber, newsprint, and woodpulp to the United States amounted to about 12 percent of the total (Statistics Canada 1974).

U.S. imports of newsprint amount to about one-half of Canadian production of all grades of paper and board and about 79 percent of Canadian newsprint exports. In 1972, the United States took 87 percent of Canada's exports of softwood lumber and 57 percent of Canadian pulp exports (Food and Agriculture Organization of the United Nations 1974). Lack of other markets for this kind of volume strengthens the argument for Canadian retaliation.

Canada would have leverage for retaliation. In 1973, Canada accounted for 21 percent of U.S. exports and 26 percent of U.S. imports (U.S. Bureau of the Census 1974a, 1974b). In addition, investments of U.S. firms in Canada amounted to $24 billion in 1971 (Council on International Economic Policy 1973). Retaliation could take the forms of withholding essential commodities--especially raw materials--from the U.S. market, duties, quotas, or elimination of imports from the United States, and confiscation or other treatment of U.S. investment in the country. Canadian energy policy is especially important to bordering U.S. States.

Hardwood veneer and plywood imports amounted to $464.7 million in 1973. The value of hardwood plywood imports amounted to $388.3 million. South Korea, Taiwan, Japan, and the Philippines were the most important sources in terms of value of shipments.

The United States is the major market for plywood produced in South Korea, Taiwan, and the Philippines. In 1972, exports from these countries, expressed in units of 1 000 cubic meters, were:

	Country of origin		
Country of destination	South Korea	Taiwan	Philippines
United States	1 062	864	277
Canada	31	177	33
Other	102	105	22
Total	1 195	1 146	332

Source: Food and Agriculture Organization of the United Nations (1974).

Further restriction of imports from these three countries would run counter to the U.S. trade philopsophy to less developed countries. As stated in the February 1974 International Economic Report of the President (Council on International Economic Policy 1974):

> Our objectives in the areas of trade, investment, and monetary reform can be jeopardized if the poorer countries are not brought into successful participation in a more open world economic system, and thereby afforded the opportunity to progress toward their development aspirations.

Any unilateral increase in U.S. import restrictions would be especially difficult in view of longstanding relationships between these three countries and the United States. These restrictions would probably also raise doubts in Malaysia and Indonesia about U.S. trade philosophy and might stimulate cartel activity in rubber and tin. Further restrictions on hardwood plywood imports might complicate future negotiations conducted according to the terms of the Trade Act of 1974. Japan will be one of the participants in these negotiations.

The Trade Act of 1974 gives the President authority, as part of negotiated trade agreements, to increase (or impose) rates of duties not to exceed 50 percent above the rate existing on January 1, 1975, or 20 percent ad valorem above the rate existing on January 1, 1975, whichever is higher. Whether an increase in the import duty would have a significant impact on U.S. forest products imports is not clear. U.S. demands for most forest products are generally believed to be inelastic. An increase in import duty would tend to raise rather than lower their total cost.

THE POTENTIAL FOR INCREASED EFFICIENCY OF DOMESTIC PROCESSING CAPACITY TO REDUCE IMPORTS AND INCREASE EXPORTS

The competitiveness of the U.S. forest products industry forces the members to keep their operations efficient. Forest products producers in Canada and Scandinavia have a similar incentive. Programs to increase the productivity of U.S. processing capacity would probably have only a marginal effect on U.S. trading patterns. Existing programs to increase productivity of U.S. processing capacity are periodic and implied in the investment tax credit and other provisions of the tax code.

THE POTENTIAL FOR INCREASED DOMESTIC SUPPLIES TO REDUCE IMPORTS AND INCREASE EXPORTS

Potential responses of U.S. timber supplies to intensified management have been discussed in the "Timber Outlook" report (USDA Forest Service 1973). The response of supply to one program amounted to 1.6 billion board feet in 1980, 2.7 billion in 1990, and 4.7 billion in 2000 (table 8). Net import volume under the assumed price conditions was 4 billion board feet in 1980, 5.2 billion in 1990, and 5.2 billion in 2000. Thus, the United States would

TABLE 8.—*Summary of softwood timber demand, exports, imports, and demand on and supply from U.S. forests, 1952, 1962, and 1970, with projections to 2000 (medium level) under alternative price and management assumptions*

BILLION CUBIC FEET

Item	1952	1962	1970	Projections								
				1970 relative prices			Rising relative prices[1]			Relative prices above 1970 averages[2]		
				1980	1990	2000	1980	1990	2000	1980	1990	2000
Total U.S. demand	8.4	8.5	9.7	12.1	14.1	15.8	11.2	12.4	13.5	10.7	12.7	14.3
Exports	.2	.4	1.2	1.7	1.6	1.6	1.7	1.6	1.6	1.7	1.6	1.6
Imports	1.3	1.7	2.1	2.3	2.3	2.3	3.1	3.7	4.0	3.2	3.6	3.7
Demand on U.S. forests	7.3	7.2	8.8	11.5	13.4	15.1	9.8	10.3	11.1	9.2	10.7	12.2
Supply from U.S. forests—base projections[3]	7.3	7.2	8.8	10.1	10.7	11.5	10.1	10.7	11.5	10.1	10.7	11.5
Supply-demand balance	------	------	------	−1.4	−2.7	−3.6	+0.3	+0.4	+0.4	+0.9	------	−.7
BILLION BOARD FEET, INTERNATIONAL ¼-INCH LOG RULE												
Total U.S. demand	39.9	41.7	47.6	58.9	66.5	72.6	51.5	54.1	55.0	48.7	55.8	61.9
Exports	.6	1.1	4.6	5.6	5.6	5.6	5.6	5.6	5.5	5.6	5.6	5.6
Imports	2.4	4.6	5.9	6.6	6.5	6.4	8.9	10.8	11.4	9.6	10.8	10.8
Demand on U.S. forests	38.1	38.2	46.2	57.9	65.6	71.8	48.2	48.9	49.1	44.7	50.6	56.7
Supply from U.S. forests—base projections[3]	38.1	38.2	46.2	48.8	50.9	54.2	48.8	50.9	54.2	48.8	50.9	54.2
Supply-demand balance	------	------	------	−9.1	−14.7	−17.6	+0.6	+1.0	+5.1	+4.1	+0.3	−2.5
Supply from U.S. forests—economic projections[4]	------	------	------	46.8	47.4	47.0	48.0	49.6	51.0	50.8	50.0	48.6
Supply-demand balance	------	------	------	−11.1	−18.2	−24.8	−0.2	−0.7	+1.9	+6.1	−0.6	−8.1
Increased supply from U.S. forests with intensified management[5]	------	------	------	------	------	------	------	------	------	+1.6	+2.7	+4.7
Supply-demand balance	------	------	------	------	------	------	------	------	------	+7.7	+2.1	−3.4

[1] Relative prices rising from their 1970 trend levels as follows: lumber—1.5 percent per year; plywood, miscellaneous products and fuelwood—1.0 percent per year; paper and board—0.5 percent per year. This would mean a cumulative increase of 62 percent for lumber by the year 2000, and 17 percent for paper and board.

[2] Relative prices of lumber and plywood 30 percent, miscellaneous products and fuelwood 15 percent, and paper and board 10 percent above their 1970 averages.

[3] Base projections of supply are defined as the amounts of timber that would be available for harvesting if: (1) forestry programs continued at 1970 levels, (2) timber removals in the East changed on a straight line basis from actual removals in 1970 to a balance with growth in the year 2000 and thereafter, (3) removals on private lands in the West followed trends suggested by recent management and operating practices, and allowable cuts on public lands remained at the 1970 level.

Source: Table 155, USDA Forest Service (1973).

[4] Projections of supply related to alternative price levels, and 1970 level of management, with some adjustments for recent environmental constraints on National Forests harvests.

[5] Increases on supply from a program of $69 million annually for commercial thinnings, planting, and timber stand improvement on areas of nonindustrial private and National Forest lands that will yield more than 5 percent return on investments. Supplies could be further increased with other investment criteria, investments in other management or utilization opportunities, or investments on other ownerships.

Note: Data may not add to totals because of rounding.

Sources: Data for 1952, 1962, and 1970 based on information published by the U.S. Departments of Commerce and Agriculture.

Projections: U.S. Department of Agriculture, Forest Service.

be a net importer, especially during the first two decades of the program. The report points out that much of the increase in supply from intensified management programs would become available only after 2000.

Only by coincidence would the product mix from intensified management programs match the mix of softwood imports. Lower prices would tend to increase consumption of forest products, including products manufactured from the timber attributable to intensified management programs. Because of this increased consumption and the product mix of imports, intensified management programs would probably not provide enough timber to eliminate imports.

EXPORT PROMOTION PROGRAMS

Reduction of barriers to trade.--Other countries have import tariffs on forest products. For example, Australia, Japan, and the European Economic Community (EEC) have tariffs on softwood lumber. Canada, EEC, Japan, Norway, Mexico, Australia, New Zealand, and Sweden have tariffs on softwood plywood. Nontariff barriers such as regrading of imported U.S. lumber and preferential tariff agreements also affect U.S. export volume. Major U.S. trade barriers are tariffs on veneer and plywood imports and a prohibition of log exports from Federal lands west of the 100th meridian.

The United States would probably have a net gain in forest products export value from free trade. A major question would be the effect on value if the restriction on log exports from Federal lands were to be lifted. This action would increase supplies of exportable logs and probably reduce export prices. If the Japanese demand for logs is inelastic, as is generally believed, the total value of log exports would decline despite increased volume.

Trade restrictions on forest products are only part of the international trade picture. The feasibility of reducing restrictions on international trade in forest products must be tested against the possible impacts on U.S. domestic and international goals. Future negotiations based on the Trade Act of 1974 will presumably include forest products trade restrictions.

Formation of U.S. export associations.--The Webb-Pomerene Act permits U.S. companies to join in export trade and, in their export sales activities, be exempt from the Sherman Antitrust Act. The act, passed in 1918, has never been a big factor in U.S. exports (Beuter 1969). Cooperation in the export market and competition in the domestic market are arduous, especially in the highly competitive forest products industry. Traditional orientation to domestic rather than to foreign markets is another indication that export associations would have only a marginal effect on forest products trade.

Subsidies for exports.--The United States has had a history of production and export subsidies for certain products, including agricultural commodities, but these subsidies are being phased out.

A subsidy for only exports would have some effects on the domestic situation also. It would be an incentive to decrease production for the home market, and this might raise domestic prices. A subsidy would, in effect, cause a redistribution of income from the general public to the forest products industry.

Government-sponsored sales programs.--The Department of Commerce cooperates with U.S. firms in foreign trade fairs and other export promotion activities. Although successful in more highly processed manufactured products, trade fairs are generally recognized as having limited success for commodities such as forest products.

Potential effects of policies to change U.S. trade flows

In the U.S. economy, response to policies is achieved through price. A change in relative prices of raw materials and producer or consumer goods initiates reactions that change output, distribution, and consumption. These changes impinge on the criteria that measure the achievement of domestic and foreign goals. Changes in relative prices caused by a change in U.S. timber supply depend on the elasticities of supply and demand of foreign and domestic forest products, substitutes, and complements.

The effectiveness of changes in timber supply for meeting domestic and international goals depends in part on policies or market forces in other parts of the economy. Price movements initiated by a change in timber supply may be countered or accentuated by price movements for substitute commodities. Trade in other commodities affects floating exchange rates which ultimately determine the ability of the United States to import or export forest products.

Without any change in policy on net imports, the "Timber Outlook" (USDA Forest Service 1973) analysis shows that substantial increases in prices of timber products relative to the general price level will be necessary to balance demands for and available supplies of timber. Intensive management programs initiated now would not have much effect on this situation until after the year 2000.

Changes in U.S. policy on net imports of forest products would reinforce the expected price increases in forest products. Tariffs or quotas to reduce forest products imports would reduce supply and raise prices. Export promotion programs would tend to raise prices by increasing demand on U.S. forests.

In the general equilibrium U.S. economy, changes in relative prices have many effects.

A price increase for forest products causes a redistribution of income from consumers to producers of forest products. In the case of a subsidy for exports, income goes from the general public to the forest products industry both through the subsidy and through higher prices. Income, in general, would be redistributed from urban areas where consumption is centered to rural producing areas.

Higher forest products prices raise the returns from growing timber relative to other uses of land. This would cause conversion of some farmland to forest land.

A price increase for forest products is an incentive for intensified forest management on private lands. Much of this investment would be concentrated in the South and the Pacific Northwest. These areas would feel the most direct impact from effects of rising forest products prices.

A price increase for forest products would tend to increase recycling of paper. However, higher prices would tend to increase the use of steel, concrete products, and aluminum. As pointed out in the "Timber Outlook" report (USDA Forest Service 1973), energy requirements and other costs of processing competing materials are much higher than for timber products.

A price increase for forest products would be felt across all sectors of the U.S. economy. Forest products are widely used for construction, packaging, and for packing in transportation; and higher prices would be reflected in higher costs for these goods and services. Effective import tariffs or quotas would initially cause shortages or other dislocations which would accentuate the tendency to higher prices.

U.S. energy consumption would probably increase in the event of either import controls or increased exports. Replacement of imported Canadian pulp and newsprint would require the equivalent of more than 50 new pulpmills. Much of this expansion would be in the South and West. Effects on energy consumption are not certain because production of other commodities would probably decline in the event of increased production of forest products. If these other industries are energy intensive, energy consumption might decrease.

The pulp industry would have difficulty finding 50 new millsites and the hundreds of millions of dollars required for major expansion. Investment in pollution control equipment continues to drain a large share of the industry's capital. Environmental effects of pulp industry expansion would probably be concentrated in the South.

The effect of import restrictions or increases in exports on U.S. employment is not clear. In a full employment situation, increases in employment in one industry are at the expense of decreases in employment in other industries (Mintz 1973). If the country has unemployment, increased forest products prices may force unemployment in other industries which must compete for labor and raw materials.

The potential effect of different import and export policies on foreign policy considerations has already been discussed.

A policy to limit forest products imports would probably not have a positive effect on the U.S. balance of payments. Exports of forest products and employment in other U.S. industries would decline in response to rising forest products prices. Exports of products from other industries would decline or imports of the products would increase. In addition, increased use of substitutes for forest products means increased use of imported materials (Mintz 1973).

A policy to promote forest products exports would probably not have a positive effect on U.S. balance of payments. Imports of forest products would rise. Employment in other industries would decline, possibly reducing their exports and increasing imports of products manufactured by those industries in other countries. Relative prices of forest products would rise, causing increased imports of substitutes.

Sources of forest products imports appear secure for the foreseeable future. Imports have kept down the rate of increase in prices. In this atmosphere, programs such as a tax on forest products consumption or additional incentives for investment in forest products processing capacity do not appear realistic. For this reason, their potential effects on domestic and international goals were not discussed.

Summary

The Nation has a mix of domestic and international goals. Policies to change forest products trade will impinge on these goals primarily through changes in the prices of forest products and other commodities. These price changes would conflict with some goals and contribute to the achievement of others. Decreases in imports or increases in exports stimulated by a change in policy would probably accentuate these effects.

This report has described options for decreasing forest products imports and increasing forest products exports. Some probable effects of these options were discussed. Evaluation of individual policies to change the pattern of forest products trade should be based on a weighting of these effects. Each policymaker can be expected to attach different weights to the effects of different policies.

The forest products trade deficit of $1.4 billion in 1973 may grow to several billion dollars by the year 2000. Under a floating exchange rate, this deficit should be of interest only as it affects domestic goals. U.S. trade in all commodities, not just forest products, determines the value of the dollar relative to other currencies. If the forest products deficit is not offset by a surplus in other commodities, the value of the dollar relative to other currencies will decline. This would cause U.S. exports to increase and imports to decrease until a balance is reached.

The United States is becoming increasingly dependent on world trade to maintain its standard of living. U.S. exports went from $48.8 billion in 1972 to $69.9 billion in 1973. The need for trade in other commodities will tend to decrease the relative importance of forest products trade in the perspective of total U.S. imports and exports.

Options to change the pattern of U.S. forest products trade are constrained because the United States is an integral part of the world economy. Policies to force changes from the status quo would cause disruptions in the world trade pattern which has developed from each country's comparative advantage and existing constraints on free trade. In the current world political climate, any policy to force a decrease in imports or an increase in exports would probably be countered by other countries.

Options to change the pattern of U.S. forest products trade are constrained because of the apparent U.S. trade philosophy. Unilateral restriction of forest products imports or subsidized exports would run counter to the idea of "fair trade" embodied within the Trade Act of 1974. The option of free trade in forest products will probably be considered in future negotiations based in part on terms of this act.

Options to change the pattern of U.S. forest products trade are constrained because of the ability of the Nation's timber resource and timber processing industry to respond to a policy which requires increased domestic production. National policies to increase domestic timber supplies would not have a significant effect on timber production until after the year 2000 even if initiated now. Capital requirements and environmental constraints would limit the ability of the industry to significantly increase capacity. This is especially true of the pulp industry. The concentration of imports in newsprint and softwood lumber would make implementation of domestic policies to replace this volume especially difficult.

Options to change the pattern of U.S. forest products trade are constrained because other trade policies and a flexible exchange rate play roles in forest products imports and exports. Under a floating exchange rate, U.S. policies on energy, agriculture, and other industries determine the total value of imports and exports. The exchange rate which evolves from this trade pattern determines in part the competitiveness of U.S. exports and the U.S. demand for imports. The effectiveness of policies designed to change forest products trade will vary with variations in the exchange rate.

These constraints lead to an apparent lack of options to significantly affect the current and prospective U.S. forest products trade pattern over the next 10 to 20 years. Within these constraints, a goal of eliminating net imports is unrealistic for the next two to three decades.

There is no clear rationale as to why the Nation should strive to eliminate net imports of timber or even to change the pattern of imports and exports of forest products. Trade policies are based on the overall balance of trade and not the balance for any one commodity or any one country. Import sources appear secure for softwoods and reasonably dependable for hardwoods. A continued reliance on forest products imports is compatible with some U.S. domestic goals and may conflict with others. A growing U.S. demand should tend to increase the compatibility of forest products imports with most domestic goals and not increase the status quo conflict with other domestic goals.

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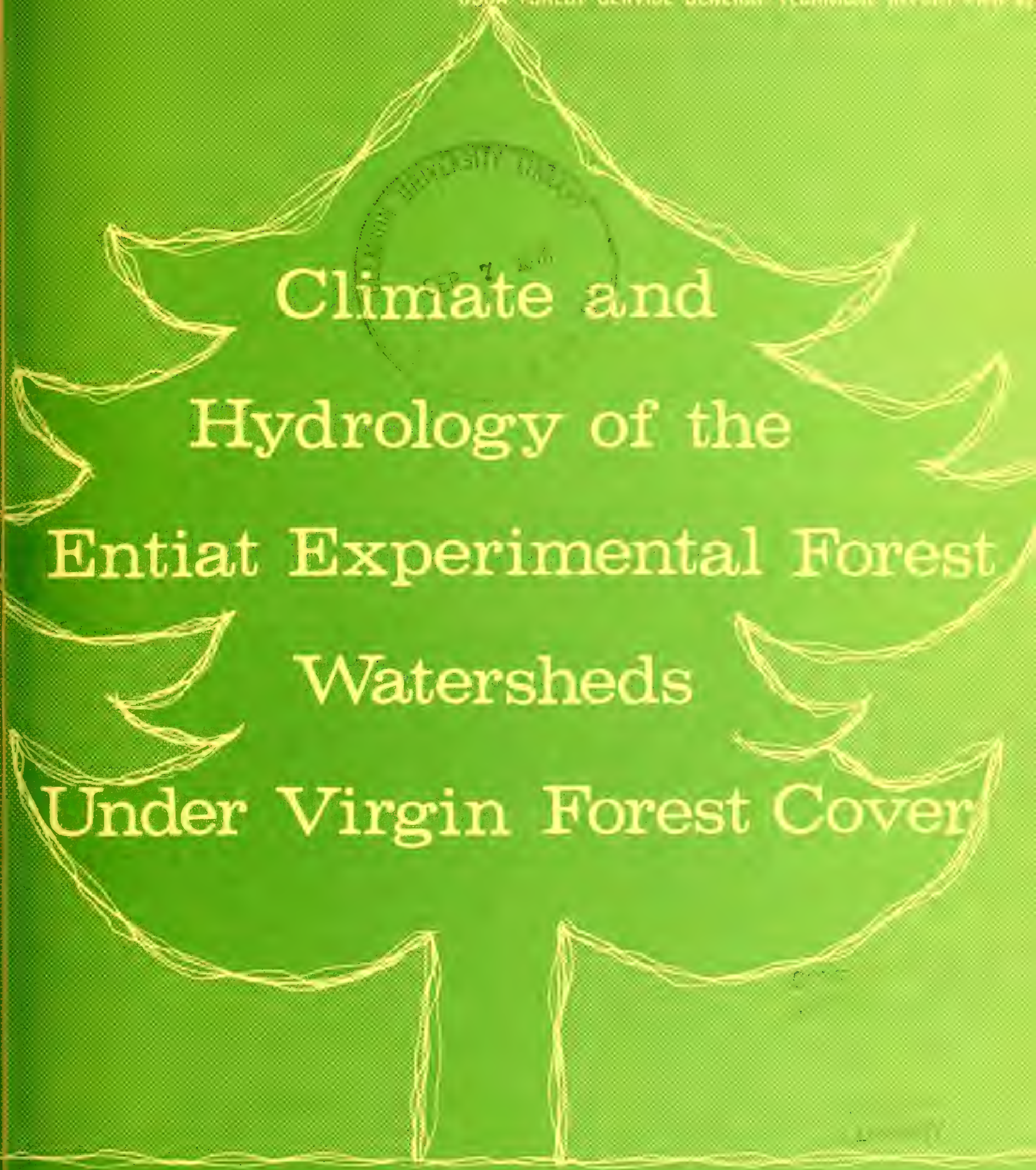

Climate and Hydrology of the Entiat Experimental Forest Watersheds Under Virgin Forest Cover

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ABSTRACT

Climatic and hydrologic measurements were made on three watersheds, each containing approximately 2 square miles (5.18 km^2) of drainage area, for 9 years under natural forested conditions. This paper describes the watersheds with respect to soils and geology, morphology, vegetation, precipitation and other climatic parameters, and flow, sediment, temperature, and chemistry of streams during this period.

KEYWORDS: Watershed management, climate variation.

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APPENDIX. 13

Water is one of the most important natural resources of the mid-Columbia region of Washington because it supports a billion dollar economy in manufacturing, agriculture, mining, and recreation. Water in the streams originates almost exclusively as rain or snow in the forested headwater areas. The U.S. Forest Service, administrator of much of the upland watersheds, recognizes the need for a balanced research program in watershed management to insure that activities related to timber harvest and recreation do not jeopardize the quantity or quality of this water supply. The need for experimental watersheds where long-term studies can be completed is also recognized.

A search for a suitable area for watershed management research in the mid-Columbia region was started in 1949. Criteria for watershed selection included (1) a series of three or more drainages of 1 to 6 square miles (2.59 to 15.54 km^2) each; (2) watersheds as nearly similar as possible in size, drainage pattern, aspect, topography, geology, soils, and cover type; (3) no disturbance by recent fire, heavy grazing, logging, or roadbuilding; and (4) reasonable access during all seasons. In 1957 after an exhaustive search, Fox, Burns, and McCree watersheds, containing 1.83, 2.18, and 1.98 square miles (4.74, 5.65, and 5.13 km^2) of drainage area, respectively, were selected for calibration. Vegetation, soils, and climate of these catchments were similar to these factors on thousands of acres of forested land in north-central Washington. Therefore, results obtained from these study sites would have wide application. Instrumentation of the watersheds began in 1959.

The original plan was to measure precipitation, air temperature and humidity, streamflow, and sediment production on each watershed for several years under natural conditions, then test for changes in quantity, quality, and timing of runoff after roadbuilding and timber harvest. Tentative objectives were to build two roughly parallel roads through McCree and Burns watersheds, study the effect of road construction on water quality for 2 years, then harvest timber from Burns watershed with a skyline system and from McCree watershed with conventional ground skidding methods such as tractors, jammers, etc. Fox watershed was to be left undisturbed to serve as a control for evaluating treatment effects.

The calibration period and timber harvest plans were nearly complete in 1970 when the entire area was burned by a wildfire caused by lightning. Since the burn, research objectives have been to evaluate the effects of wildfire and subsequent revegetation on water yield, stream temperature, stream chemistry, soil moisture, air temperature, and rates of revegetation. The objective of this paper is to describe the prefire watershed conditions with respect to location, topography, soils, vegetation, precipitation, and the patterns, temperature, and chemistry of streamflow. These data will be a useful addition to the hydrologic information collected from small, undisturbed watersheds in the United States. Also, this paper will serve as a reference, and the detailed information presented here will not need repeating in our future reports which describe postfire conditions.

LOCATION AND TOPOGRAPHY

The experimental watersheds (fig. 1) are located on the east slope of the Cascade Range in north-central Washington at latitude 47° 57' N and longitude 120° 28' W. Drainage is generally toward the southwest to the Entiat River which joins the Columbia River at Entiat, Washington. A glacier during the Wisconsin stage of the Pleistocene epoch scoured this part of the Entiat River, leaving the tributary streams as hanging valleys above the present valley floor. Consequently, the profiles of Fox, Burns, and McCree Creeks have

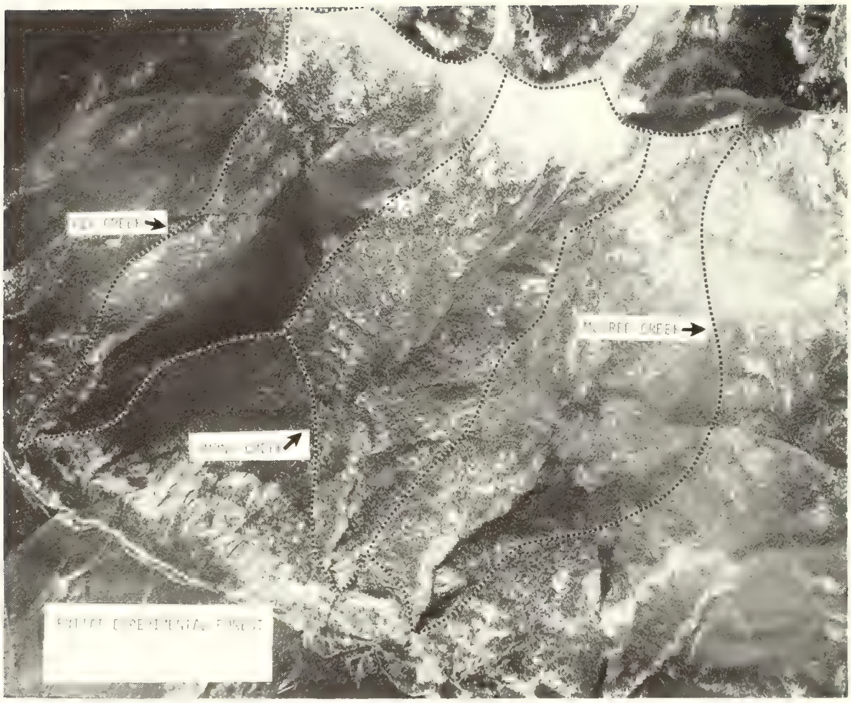

Figure 1.--Aerial mosaic of the three watersheds on the Entiat Experimental Forest.

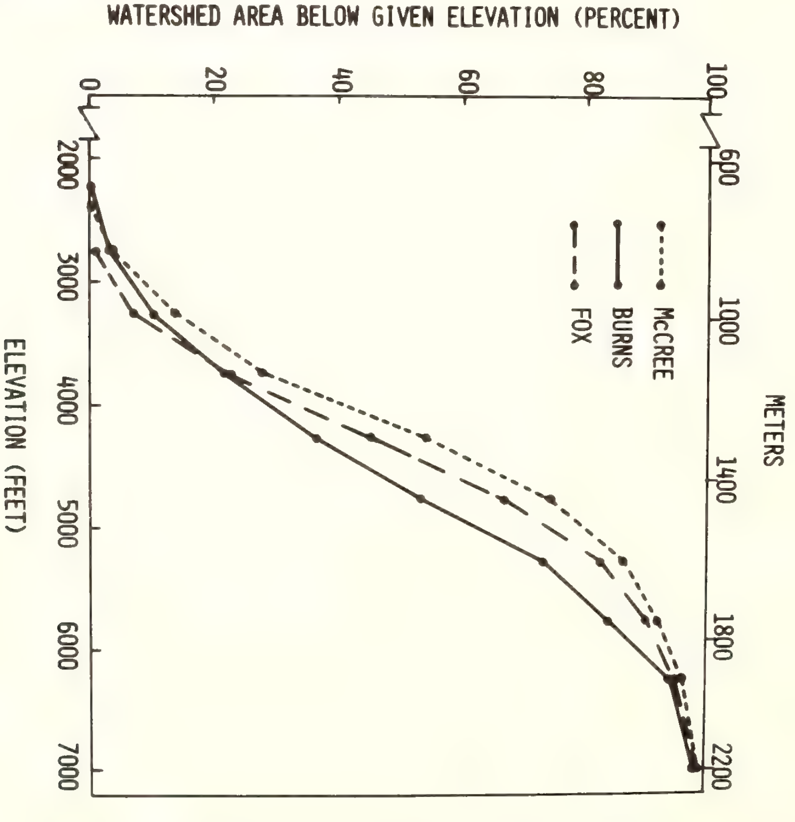

Figure 2.--Area-elevation relationships for the three experimental watersheds.

Table 1--*Summary of some physical characteristics for three experimental watersheds in north-central Washington*

Physical factor	McCree	Burns	Fox
Area, mi^2	1.98	2.18	1.83
(km^2)	(5.13)	(5.65)	(4.74)
Mean aspect azimuth, degrees	210	205	237
Drainage density, mi mi^{-2}	2.62	2.07	2.09
(km km^{-2})	(1.63)	(1.29)	(1.30)
Mean channel gradient, percent	29	27	27
Elevation range, ft	2,120-7,050	2,760-7,070	1,980-7,100
(m)	(646-2 149)	(841-2 155)	(603-2 164)
Mean elevation, ft	4,420	4,600	4,900
(m)	(1 347)	(1 402)	(1 494)
Annual radiation index,[1] percent	51.5	50.7	47.2

[1] Computed by the methods of Lee (1963) and defined by him as "the ratio between the daily total of potential insolation on that surface to the total of potential insolation which would be received on a surface that is constantly normal to the sun's rays during the possible daylight hours."

gradients of 40 to 70 percent in the glaciated area and more gentle gradients in the upper reaches. Mountain glaciers apparently did not form within the watersheds, but glacial cirques are evident in figure 1 north of the watershed divide.

Watershed elevations range from about 1,800 to 7,000 feet (549 to 2 134 m) above sea level. The mean land slope is about 50 percent, but slopes of 90 percent are common. Figure 2 illustrates the relationship between area and elevation; other physical characteristics of the watersheds are presented in table 1.

Fire scars on large trees indicate a history of periodic fires. Age of trees indicates that a fire similar to the one experienced in 1970 probably has not occurred during the past 200 years. Keen (1940) and Daubenmire and Daubenmire (1968) show fire occurring periodically from 15 to 36 years in eastern Washington, but these were principally ground fires that reduced understory fuels and scarred lower parts of the trees.

GEOLOGY AND SOILS

Bedrock throughout the watersheds consists primarily of granodiorite and quartz diorite. During the Pleistocene period of glaciation, large amounts of fluvoglacial materials accumulated in the lower section of each drainage. Since the glacial period, much of the watersheds has been deeply covered by pumice and ash deposits, mostly originating from Glacier Peak 35 miles (56 km) to the northwest. There appear to be six different periods of volcanic deposits which presently range in depth from a few inches to more than 20 feet (6 m). There is no evidence of soil profile development in the glacial till and weathered diorite beneath the ash and pumice.

Two major soil series, both Entisols, have been identified on the watersheds. Choral soils occupy about 55 percent of the area. Rampart soils occupy about 35 percent with Rockland and rock outcrops accounting for 10 percent. The Choral soils are well drained and moderately coarse textured. Rampart soils are similar to Choral, but they occur at lower elevations and have developed under warmer climatic conditions. A description of the physical properties of a typical undisturbed Choral profile taken at the 5,000-foot (1 524-m) elevation is given in table 2. Total nitrogen in the surface soil is generally below 0.10 percent. Surface soil pH is about 6.0, and cation exchange capacity is normally less than 10 meq/100 g. The major zone of root activity is 24 inches (61 cm) or less.

Table 2--*Soil physical properties of a representative Choral series profile located on the Entiat Experimental Forest*

Depth (cm[1])	Bulk density[2]	Percent moisture			Soil texture						Color and material
		0.1 bar	1.0 bar	15 bars	>4 mm	2-4 mm	1-2 mm	1 mm-50μm	Silt, 50μm-2μm	Clay, >2μm	
	(gm cm^{-3})										
0-9	1.26	56.5	13.6	8.4	0	0	0	89.3	10.7	0	10YR 7/1 ash
10-62	.74	60.9	15.5	12.0	17.5	15.3	8.7	29.4	29.0	0	10YR 7/4 ash and pumice
63-119	.50	73.1	29.6	17.0	30.2	32.4	17.1	20.5	--	--	2.5Y 8/2 "popcorn" pumice
120-129	1.44	21.6	11.0	5.4	0	6.1	10.3	47.9	35.7	1.7	10YR 7/6 ash
130-159	.52	51.8	16.9	6.9	38.4	23.9	17.5	20.2	--	--	2.5Y 8/2 "popcorn" pumice
160-161	1.44	21.6	11.0	5.4	0	6.1	10.3	47.9	35.7	1.7	10YR 7/6 ash
>161	2.01	12.9	4.9	3.3	33.6	15.9	11.6	30.5	8.5	0	2.5Y 7/4 buried soil material

[1] 1 centimeter = 0.39 inch.

[2] 1 gm cm^{-3} = 62.4 pounds foot^{-3}.

VEGETATION

Before the fire, the area supported a mature stand of timber in which ponderosa pine (*Pinus ponderosa* Laws.) and Douglas-fir (*Pseudotsuga menziesii* (Mirb.) Franco) were the dominant species. Other overstory species included lodgepole pine (*Pinus contorta* Dougl.), western redcedar (*Thuja plicata* Donn), and whitebark pine (*Pinus albicaulis* Engelm.). A timber cruise in 1967 indicated volume summary:

Watershed	Total area		Timber volume	
	mi^2	km^2	Thousand bd ft[1]	m^3[2]
McCree	1.98	5.13	23,368	55 113
Burns	2.18	5.65	19,363	45 668
Fox	1.83	4.74	11,563	27 271

Vegetation on side slopes between 1,800- and 3,000-foot (549- and 915-m) elevation consisted of an overstory of ponderosa pine with an understory of bitterbrush (*Purshia tridentata* (Pursh DC.))[3] and serviceberry (*Amelanchier alnifolia* Nutt.). Arrowleaf balsamroot (*Balsamorhiz* *sagittata* (Pursh) Nutt.), bracken fern (*Pteridium aquilinum* (L.) Kuhn.), spreadin dogbane (*Apocynum androsaemifolium* L.), and bluebunch wheatgrass (*Agropyron spicatum* (Pursh) Scribn. and Smith) were prominent herbaceous species. This zone is probably representative of the *Pinus ponderosa/Purshia/Agropyron* habitat type of Daubenmire and Daubenmire (1968). At elevations between 3,000 and 5,500 feet (915 to 1 676 m), Douglas-fir became more prominent, often occurring in almost pure stands on moister sites. Lodgepole pine normally occurred only in small, dense thickets. However, the southwest slope of Fox Creek was an almost pure stand of "doghair" lodgepole pine. Snowbrush ceanothus (*Ceanothus velutinus* Dougl.), willow (*Salix* spp.), and Sitka alder (*Alnus sinuata* (Reg.) Rydb.) were common shrubs. Half-shrubs and low shrubs consisted primarily of Oregon boxwood (*Pachistima myrsinites* (Pursh) Raf.), birchleaf spiraea (*Spiraea betulifolia* Pall.), princess pine (*Chimaphila umbellata* (L.) Bart.), and kinnikinnick (*Arctostaphylos uva-ursi* (L.) Spreng.). Of the herbaceous species, pinegrass (*Calamagrostis rubescens* Buckl.), Ross sedge (*Carex rossii* Boott), spiraea, dogbane, and bracken fern were prominent. The intermediate elevations are characteristic of the *Pseudotsuga menziesii/Calamagrostis rubescens* habitat type described by Daubenmire and Daubenmire (1968). At elevations above 5,800 feet (1 768 m), whitebark pine was commonly encountered. A list of understory plants encountered is presented in the appendix.

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[1] 1 board foot equals 1/12 cubic foot.

[2] 1 cubic meter equals 423.6 board feet.

[3] Plants were identified by F. J. Hermann and Charles Feddema of the National Herbarium at Fort Collins, Colorado.

SOLAR RADIATION

Solar radiation available to surfaces within the experimental watersheds as a function of slope and aspect is expressed in the radiation index in table 1. This parameter indicates the radiation input to the watersheds compared with a slope constantly normal to the sun's rays. Variation between these values is very small, but Fox watershed receives slightly less radiation than the other two.

Daily total hemispheric radiation (sun plus sky) at two stations is shown in figure 3. Junior Point Lookout is located 3 miles (4.8 km) north of the Experimental Forest watersheds at 6,676-foot (2 035-m) elevation. Steliko Lookout is located 11 miles (17.7 km) south-southeast of the watersheds at 2,580-foot (786-m) elevation. Two features of this graph are important. Radiation input is generally greater at the higher station--31 points lie above the 1:1 line, 19 below. There were a number of days during this period (midsummer of 1963) when the more northerly and higher station (Junior Point) had radiation input reduced by cloud cover. Differences

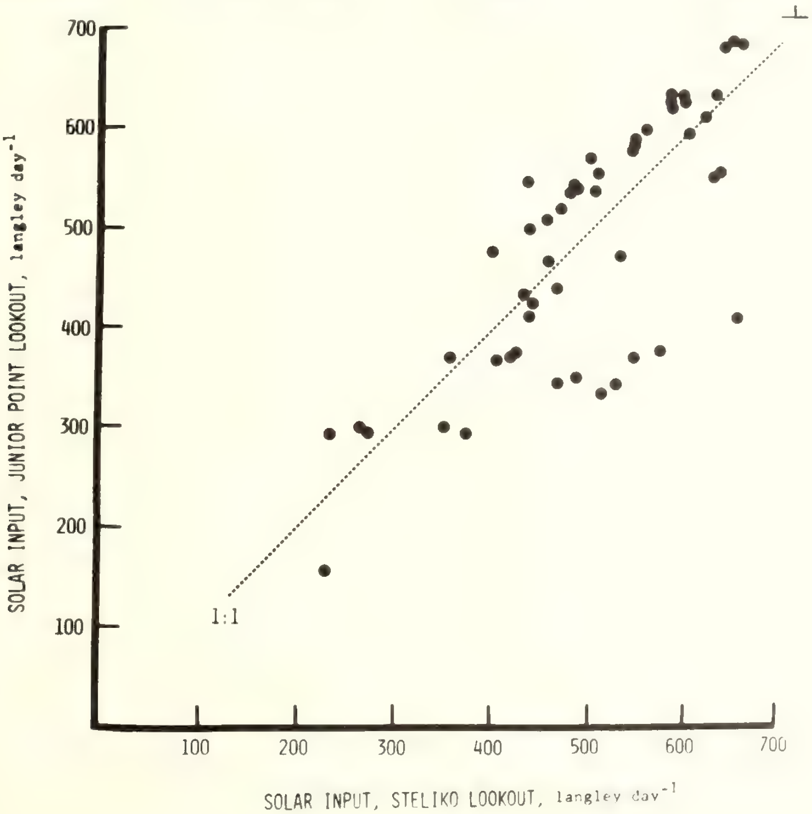

Figure 3.--Daily radiation input at two stations near the Experimental Forest boundary. Dashed line indicates 1:1 slope.

in elevation and variable cloud cover change receipt of the solar radiative input rapidly over short distances in mountainous terrain.

PRECIPITATION

Annual precipitation at 3,000-foot (915-m) elevation ranged from 8 to 31 inches (20.3 to 78.7 cm) and averaged 22.4 inches (56.9 cm) between 1961 and 1970 (appendix table 4). Usually, measurable precipitation falls during each month, but on the average only 14 percent of the annual total occurs from May through September. Annual precipitation and temperature are shown in figure 4. Summertime precipitation may occur as potentially high intensity convective storms of short duration. Snow accounts for about 70 percent of average annual precipitation. Precipitation increases with elevation and also from east to west (toward the Cascade crest) although the amount has not been accurately defined. The precipitation network has been expanded, and this should help to clarify effects of elevation on amounts of precipitation.

AIR TEMPERATURE

An interesting feature of the graph of mean monthly air temperature (fig. 4) is the lag in response compared with solar heating. A lag of 1 month in temperature from the summer solstice is quite common at inland midlatitude stations. At the Burns Creek site, maximum mean monthly temperatures occur in August with the September average well above the June average. This 2-month lag of maximum monthly temperatures behind the solstice is unique compared with other stations in this area. Typical nearby mountain stations--Stevens Pass, Snoqualmie Pass, and Blewett Pass--although higher in elevation than the Burns Creek site and with deeper, longer duration snowpacks, show only a 1-month lag. Extreme sites--Mount Baker, 4,150 feet (1 265 m) and Mount Rainier (Paradise), 5,500 feet (1 676 m)--show

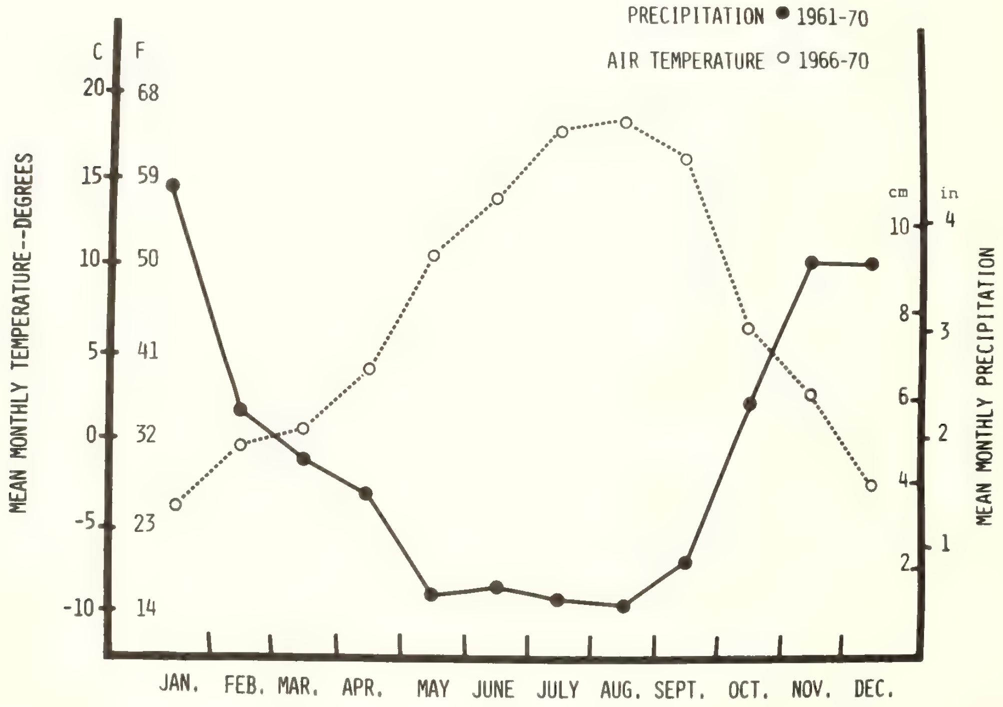

Figure 4.--Average monthly values of temperature and precipitation at 3,000-foot (915-m) elevation on Burns watershed.

a 2-month lag. Energy use in snowmelt and evaporation with local cold air drainage may delay substantially the early season rise in temperature. The record of only 4 years may not represent the long-term average condition at this site. More detailed studies of the thermal regime are underway.

Soil and plant surfaces are the active zone for the transformation of solar and infrared energy into sensible and latent heat (i.e., heating of the air and evaporating water). These energy use pathways create differences in the temperature of the active surface, differences which are a complex function of the physical characteristics, amount of cover, type of plant, age, height, etc. With an infrared thermometer and a photorecording system, measurements of the watersheds' surface temperatures were made on August 29, 1969. Measurements were taken during a 40-minute period from elevations of 200 to 300 feet (61 to 91.5 m) near the time of maximum air temperature (1330 hours). Sky conditions were clear. Of the 1,500 plus measurements taken during this flight, only midslope flight lines were selected for analysis here. Results are shown below.

	Mean surface temperature		Standard deviation		Number of photos
	°F	°C	°F	°C	
East-side McCree watershed	67.6	19.8	4.5	2.5	103
West-side McCree watershed	72.5	22.5	6.3	3.5	135
East-side Burns watershed	68.0	20.0	6.1	3.4	115
West-side Burns watershed	73.0	22.8	7.7	4.3	117
East-side Fox watershed	68.2	20.1	5.0	2.8	122
West-side Fox watershed	73.2	22.9	6.5	3.6	101

Although mean temperature in each watershed was higher on west sides, the variation between measurements was also greater. The null hypothesis of no significant difference between these aspects could not be rejected at the 0.10 probability level. Therefore, although a diversity of vegetal types and elevations was covered, an overall similarity of surface temperatures was found between the watersheds. Comparisons will be made with surface temperatures at other seasons and after vegetative manipulation of these watersheds.

STREAMFLOW

Streamflow was measured with sharp-crested, 120°, V-notch weirs and instruments to continuously record water levels. Streamflow patterns are typical of areas in which precipitation is mostly in the form of snow. Snowmelt produces peak flow rates in May or June with a gradual decline to the annual low and fairly steady rate in September (fig. 5). Because flow is usually minimum in September, the water year is defined as extending from October 1 to September 30. Monthly water yield data from the three drainages between 1962 and 1970 are presented in appendix table 5.

Flow duration curves give a clear picture of the flow characteristics of a stream by indicating the percentage of time a selected discharge rate was equaled or exceeded during the period of interest. These curves were computed from mean daily discharge for each watershed during the period 1962-70 (fig. 6). Flow rates from McCree watershed were greater than 0.45 ft^3 sec^{-1} (12.7 liter sec^{-1}) during 50 percent of the time. Comparable values for Fox and Burns watersheds were 0.68 and 0.73 ft^3 sec^{-1} (19.2 and 20.7 liter sec^{-1}), respectively. Minimum rates recorded were 0.16, 0.37, and 0.38 ft^3 sec^{-1} (4.5, 10.5, and 10.8 liter sec^{-1}), respectively, from McCree, Fox, and Burns watersheds. The lower flow rates from McCree watershed may be partly caused by the slightly higher radiation index (table 1) and by lower rainfall amounts compared with the other two watersheds. Also, the higher timber volume comprised largely of Douglas-fir on McCree watershed may have had an effect. For example, Lopushinsky and Klock (1974) found that the transpiration rates of Douglas-fir seedlings were less affected by moderate soil drying than

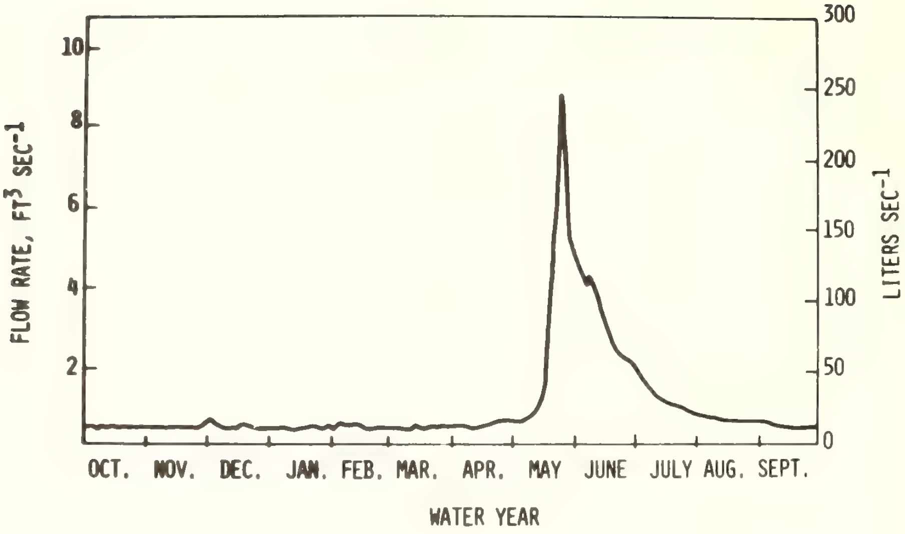

Figure 5.--The 1966-67 hydrograph from Burns Creek.

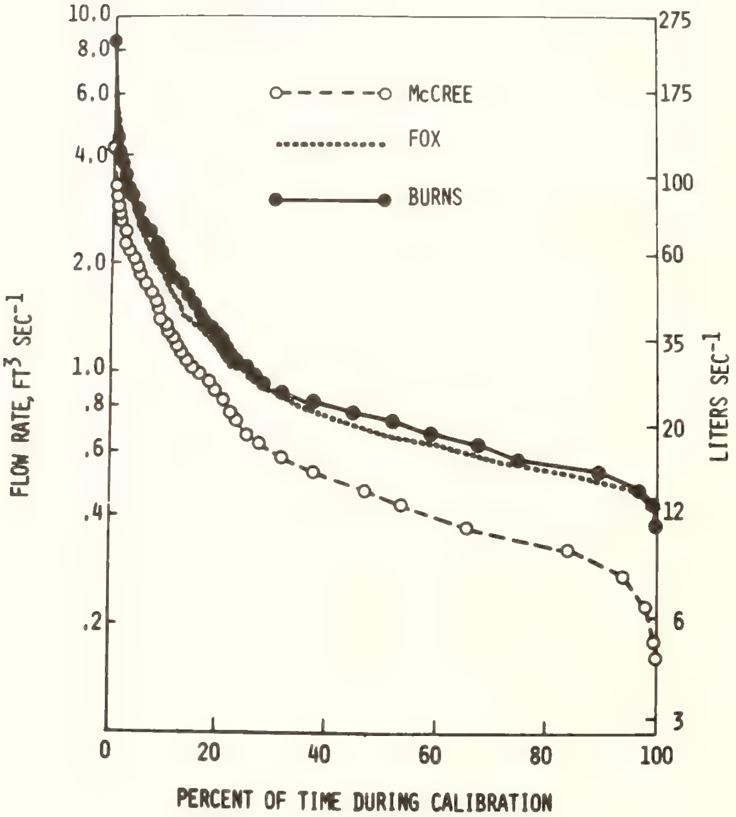

Figure 6.--Flow duration curves for the three watersheds.

transpiration rates of ponderosa pine and lodgepole pine. Also Helvey (1974), in a summary of rainfall interception by conifers, concluded that interception loss from Douglas-fir is greater than from the pine species.

Morisawa (1968) stated that the shape of the flow duration curve gives a clue to the water yield characteristics of the drainage basin; i.e., "if the curve is fairly flat, there is substantial storage, either on the surface or as ground water which tends to equalize the flow." The curves in figure 6 for the three watersheds are very flat compared with curves for other areas of comparable size but with different precipitation forms or amounts. For example, the ratio of maximum to minimum flow rates on these watersheds ranges from 23 to 37. Comparable values for 150- to 250-acre (60.7- to 101.2-ha) watersheds on the western slopes of the Oregon Cascade Range are about 1,800 (Rothacher et al. 1967). The relatively flat curves in figure 6 reflect a combination of factors including moisture storage on the surface as snow during the winter months, slow rates of melting in the spring because of gradual warmup, deep soils along the streams which release water slowly during dry summer months, and the lack of large rainfall events common to the west slope of the Cascade Range.

Pronounced diurnal fluctuations in flow rates are evident during spring runoff because of fluctuating snowmelt rates and during summer months when daytime evapotranspiration demands are high (fig. 7). Daily peaks in summer months occur during early morning hours following the daily minimum transpiration demand. As transpiration losses increase during the day, flow rates decrease and reach a minimum value about sundown. Flow patterns are reversed during spring snowmelt; i.e., daily maxima occur at night and minima at midday just before appreciable snowmelt begins.

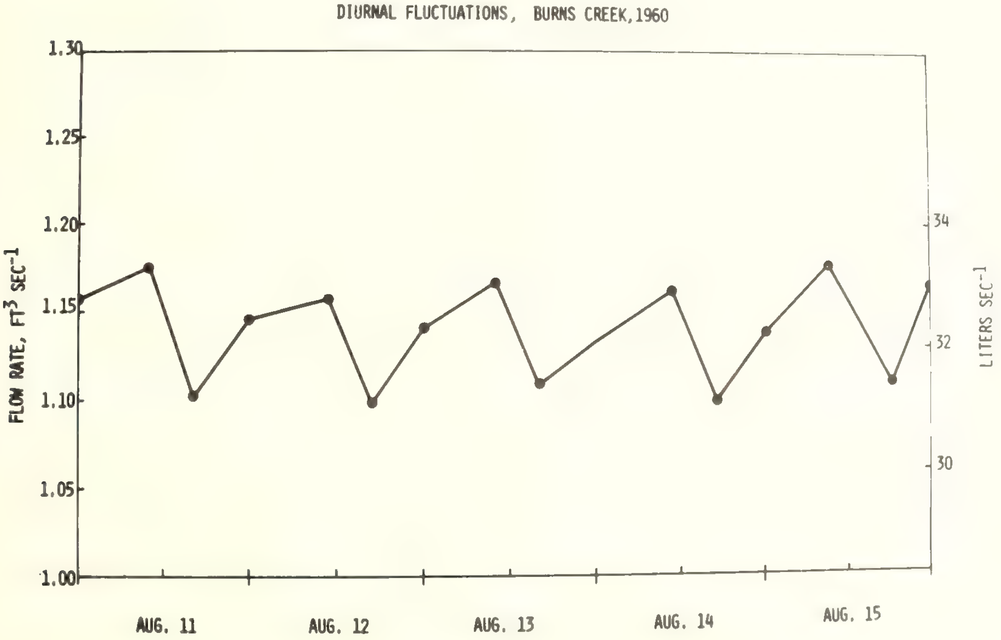

Figure 7.--Diurnal fluctuations of runoff from Burns Creek during midsummer.

WATER TEMPERATURE

Water temperature recorders were installed at each stream gaging station in 1968. As expected, water temperature trends follow closely the annual trend of air temperature during summer months. The streams are snow covered during winter months and air temperature has little or no influence on stream temperature (fig. 8). Daily maximum water temperatures during December to February 1970 averaged about 38° F (3.3° C) compared with 30° F (-1.1° C) for air temperature. Maximum water temperatures of 50-52° F (10-11° C) occur in July and August when maximum air temperature is near 90° F (32.2° C).

SEDIMENTATION

The watersheds were stable under natural conditions and sediment trapped by weir dams was extremely low. In fact, weir ponds on McCree and Burns watersheds did not require cleaning between 1961 and 1970. Fox Creek flows through an area where side slopes are oversteepened and sparsely vegetated between 2,800- and 3,000-foot (845- and 915-m) elevations. Soil material dry-raveled into the stream channel during the summer months, and spring runoff carried it to the weir pond where it was trapped. Annual bedload from Fox Creek ranged from 5 to 18 tons (4.5 to 16.3 metric tons) and averaged 12 tons (10.9 metric tons) between 1966 and 1970.

Unfortunately, there are no data for suspended sediment production. This is a serious oversight because one main objective of the research program was to test for changes in total sediment production after roadbuilding and timber harvest. Some recent data from Lake Creek, located immediately west of Fox Creek and still undisturbed, gives a clue to the suspended sediment amounts from the experimental watersheds. The values from Lake Creek during the 1975 spring runoff were always less than 6 milligrams per liter--most of the

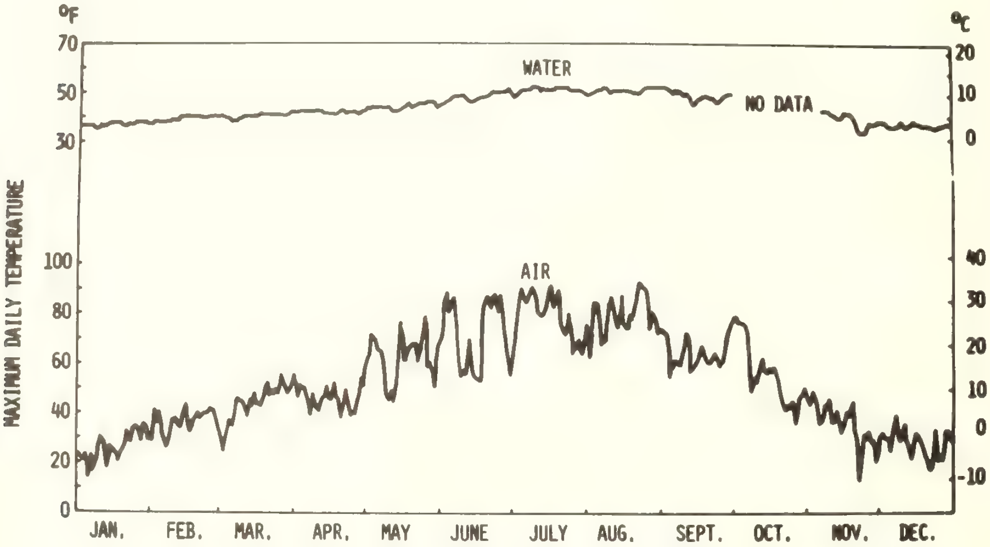

Figure 8.--Plottings of air temperature and water temperature on Burns Creek.

samples contained only 1 milligram per liter. Applying these values to the measured runoff from the experimental watersheds indicates an annual yield of less than 10 pounds per acre (11.2 kg per ha) per year.

CHEMISTRY OF STREAMFLOW

Measurements of dissolved chemicals and water chemistry were initiated in April 1970. Although the period of record before the fire is short, results indicate chemical stability of the watersheds under forested conditions. The most salient feature of water chemistry measurements was the low concentration of nitrogenous constituents (table 3). Results for nitrate nitrogen are a contrast to the concentrations observed at the mouth of the Entiat River where the levels ranged from 0.1 to 0.7 mg/liter (U.S. Geological Survey 1965). Values for concentrations of Ca, Mg, Na, K, electrical conductivity, pH, and total alkalinity were similar to those observed by the U.S. Geological Survey (1965) at the mouth of the Entiat River.

DISCUSSION AND CONCLUSIONS

The Entiat Experimental Forest was dedicated for the purpose of studying the effects of forest management on the water resource in the 20- to 30-inch (50.8- to 76.2-cm) annual precipitation zone of north-central Washington. Unfortunately, wildfire swept the entire area just as the calibration period was being completed; and the original objectives could not be fulfilled. Although the fire was a serious loss to planned watershed management research, it has provided a unique opportunity in the Northwest to study the effects of complete deforestation by fire on the quantity and quality of runoff and on other watershed values. This opportunity was possible only because the calibration data were available for comparison with postfire data.

The calibration data presented in this paper indicate that the watersheds were stable under forested conditions and that streamflow was extremely pure chemically. Quantity, quality, and timing of streamflow from other forested

Table 3--*Chemistry of streams on the Entiat Experimental Forest, April-August 1970*

Constituents or characteristics	Fox Creek			Burns Creek			McCree Creek		
	Average	Maximum	Minimum	Average	Maximum	Minimum	Average	Maximum	Minimum
NH^3(mg/liter)[1]	0	0		--	0.002		0.002	0.005	
Kjeldahl N (mg/liter)	0.042	0.071		0.045	.068		.082	.188	
NO^3-N (mg/liter)	.006	.016		--	.003		.001	.004	
Urea N (mg/liter)	0	0		.005	.025		.004	.010	
Na (mg/liter)	2.5	2.8		2.5	3.1		3.0	3.7	
K (mg/liter)	1.2	1.3		1.0	1.3		1.2	1.4	
Mg (mg/liter)	1.1	1.1		1.2	1.5		1.6	2.1	
Ca (mg/liter)	4.7	12.4		6.7	8.5		9.0	11.7	
Total alkalinity (meq/liter)	.58	.68		.65	.89		.57	.66	
Electrical conductivity (micro mhos/cm)[2]	47	66	33	41	54	36	54	70	42
pH	7.1	7.5		7.2	7.6		7.1	7.6	

[1] 1 mg liter^{-1} = 2.72 pounds $(\text{acre-foot})^{-1}$

[2] Taken from 1968 to 1970 (April-August).

areas in north-central Washington with similar geology and soils and comparable amounts of precipitation should be similar to the values presented in this paper.

POSTFIRE RESEARCH PROGRAM

Although the main objective of this paper is to describe the watersheds under prefire conditions, some readers may be interested in postfire activities. As of June 1, 1975, 12 papers dealing with nutrient cycling, water chemistry, yield, and temperature changes, vegetation dynamics, and economic impacts had been published, and 3 others were in press (see appendix). Also, a preliminary model was developed by J. Paul Riley (Utah State University) for predicting daily runoff from inputs of precipitation, air temperature, and ground water conditions.

Watersheds of the Entiat Experimental Forest still possess considerable research value for enhancing our knowledge of dynamics of the recovery process after wildfire in north-central Washington. Also, with an extensive prefire and postfire data base, the watersheds can serve in the future as a natural setting for a socioeconomic analysis of the consequences of various resource management alternatives. Thus, we are continuing to monitor water yield and chemistry, sediment production, soil moisture, precipitation, air temperature, and vegetation dynamics.

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APPENDIX

LIST OF UNDERSTORY PLANTS OF THE ENTIAT EXPERIMENTAL FOREST

Shrubs

Ceanothus velutinus Dougl.
Salix spp.
Alnus sinuata (Reg.) Rydb.
Spiraea betulifolia Pall.
Pachistima myrsinites (Pursh) Raf.
Arctostaphylos uva-ursi (L.) Spreng.
Chimaphila umbellata (L.) Bart.
Vaccinium spp.
Purshia tridentata (Pursh) DC.
Prunus emarginata (Dougl.) Walp.
Rubus spp.
Amelanchier alnifolia Nutt.
Ribes spp.

Grasses and Grasslike

Calamagrostis rubescens Buckl.
Carex rossii Boott
Poa sandbergii Vasey
Agropyron spicatum (Pursh) Scribn. & Smith
Bromus carinatus H. & A.
Oryzopsis exigua Thurb.
Stipa occidentalis Thurb.
Bromus tectorum L.

(Continued)

Forbs

Lomatium brandegei (Could. & Rose) Macbr.
Lupinus sulphureus Dougl.
Calochortus lyallii Baker
Montia perfoliata (Donn) Howell
Sphaeralcea spp.
Anaphalis margaritacea (L.) B. & H.
Luina nardosmia (Gray) Cronq.
Senecio integerrimus Nutt.
Smilacina racemosa (L.) Desf.
Sedum stenopetalum Pursh
Erythronium spp.
Hydrophyllum capitatum Dougl.
Eriogonum spp. Michx.
Allium spp.
Clarkia rhomboidea Dougl.
Pteridium aquilinum (L.) Kuhn.
Apocynum androsaemifolium L.
Epilobium angustifolium L.
E. paniculatum Nutt.
Collinsia parviflora Lindl.
Cryptantha simulans Greene
Hieracium cynoglossoides Arv.-Touv.
H. albiflorum Hook.
Mentzelia dispersa Wats.
Gayophytum nutallii T. & G.
Achillea millefolium L.
Collomia grandiflora Dougl.
Collomia tinctoria Kell.
Balsamorhiza sagittata (Pursh) Nutt.
Phacelia hastata Dougl.
Zigadenus paniculatus (Nutt.) Wats.
Arnica cordifolia Hook.
Polygonum majus (Meisn.) Piper
Arenaria macrophylla Hook.
Erysimum asperum (Nutt.) DC.
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Table 4--*Monthly precipitation at 3,000 feet (915 m), near Burns Creek weir*

(In inches[1/])

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
1961[2/]	1.6	6.4	1.9	3.3	5.0	3.9	1.0	1.3	0.2	1.2	0.4	1.7	27.9
62	1.4	3.0	3.0	(3/)	(3/)	3.0	2.7	1.3	.4	(3/)	.9	(3/)	--
63	4.0	5.0	2.9	2.1	3.8	1.0	4.7	.7	.2	1.3	1.0	0.7	27.4
64	1.8	7.2	2.7	6.4	.6	2.0	.4	.1	1.5	.1	.6	2.3	25.7
65	.3	3.7	6.0	5.6	2.3	.6	1.8	.4	.5	1.0	1.2	.4	23.8
66	.5	2.0	3.1	5.5	.9	1.8	0	.6	1.3	1.1	0	.2	17.0
67	2.0	3.8	3.0	1.0	.8	1.9	2.4	.2	.8	0	0	.3	16.2
68	9.5	1.9	4.2	5.8	3.6	1.6	.3	.7	.6	0	.8	1.8	30.8
69	1.9	3.1	7.6	5.6	2.5	1.5	1.0	.4	.8	.1	0	.4	24.9
70	.3	.5	2.2	2.8	.7	.6	.5	0	0	.1	0	.1	7.8
Average	2.33	3.66	3.66	4.23	2.24	1.79	1.48	.57	.63	.54	.49	.88	22.4

[1/] 1 inch = 2.54 cm.

[2/] Water year 1961 extends from October 1960 to September 1961, etc.

[3/] Missing data.

Table 5--*Streamflow from three experimental watersheds on the Entiat Experimental Forest, 1962-70*

(In inches[1/])

Water year	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Total
							BURNS CREEK						
1962	0.40	0.37	0.38	0.37	0.36	0.40	1.02	0.75	0.65	0.43	0.35	0.29	5.77
1963	.29	.31	.36	.37	.33	.45	.43	1.25	.80	.44	.33	.28	5.64
1964	.27	.26	.27	.28	.26	.29	.45	1.37	1.07	.50	.34	.28	5.64
1965	.27	.26	.27	.26	.28	.47	.92	1.50	.99	.51	.37	.31	6.41
1966	.29	.27	.28	.27	.24	.30	.82	.97	.48	.36	.28	.23	4.79
1967	.22	.23	.26	.24	.24	.26	.28	1.84	1.55	.66	.38	.29	6.45
1968	.30	.35	.38	.37	.58	.89	.82	1.41	.82	.51	.39	.34	7.16
1969	.35	.32	.30	.21	.25	.34	.95	2.37	1.04	.58	.43	.36	7.50
1970	.35	.32	.33	.31	.29	.38	.39	1.26	.74	.40	.30	.27	5.34
Average	.304	.299	.314	.298	.314	.420	.675	1.413	.904	.488	.352	.294	6.08
							FOX CREEK						
1962	.44	.41	.40	.41	.43	.39	.59	.77	.83	.54	.40	.31	5.90
1963	.33	.37	.36	.32	.33	.37	.43	.99	1.14	.62	.42	.33	6.01
1964	.32	.32	.31	.30	.28	.33	.37	.90	1.49	.74	.47	.36	6.19
1965	.33	.31	.31	.32	.35	.37	.60	1.50	1.46	.71	.47	.37	7.10
1966	.33	.32	.32	.30	.27	.36	.44	1.01	.66	.45	.32	.25	5.03
1967	.26	.27	.31	.29	.27	.28	.29	1.42	2.44	.93	.50	.36	7.62
1968	.40	.36	.39	.44	.59	.81	.73	1.93	1.45	.74	.57	.48	8.89
1969	.46	.46	.43	.35	.30	.48	.78	2.75	1.69	.92	.65	.54	9.81
1970	.47	.41	.39	.37	.34	.41	.39	.88	.99	.57	.38	.34	5.94
Average	.371	.359	.358	.344	.351	.422	.513	1.350	1.350	.691	.464	.371	6.94
							MCCREE CREEK						
1962	.28	.27	.27	.31	.30	.29	.75	.60	.51	.26	.20	.16	4.20
1963	.21	.27	.29	.25	.32	.33	.38	.95	.52	.25	.18	.14	4.09
1964	.17	.19	.19	.20	.22	.30	.43	1.00	.87	.26	.18	.16	4.17
1965	.17	.18	.19	.24	.33	.43	.81	1.21	.71	.28	.20	.17	4.92
1966	.17	.19	.18	.18	.17	.30	.60	.89	.32	.19	.12	.10	3.41
1967	.13	.16	.21	.19	.23	.21	.26	1.34	1.23	.30	.16	.12	4.54
1968	.20	.20	.23	.39	.49	.72	.55	1.21	.62	.28	.22	.18	5.29
1969	.21	.20	.23	.22	.21	.47	.87	1.48	.40	.25	.34	.26	5.14
1970	.21	.20	.20	.28	.24	.28	.29	.96	.48	.17	.13	.23	3.67
Average	.194	.207	.221	.251	.279	.370	.549	1.071	.629	.249	.192	.169	4.38

[1/] 1 inch = 2.54 cm.

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selecting forest residue treatment alternatives using goal programing

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ABSTRACT

The use of goal programing for selecting forest residue treatment alternatives within a multiple goal framework is described. The basic features of goal programing are reviewed and illustrated with a hypothetical problem involving the selection of residue treatments for 10 cutting units. Twelve residue-regeneration treatment combinations are evaluated, using physical, economic, and environmental goals. Empirical results are reported for four different goal priority sets. An interpretation of the sensitivity of the optimal treatment schedule associated with each priority set is also presented. Results indicate that goal programing offers considerable promise as an operational decisionmaking tool. Unresolved problems include: the selection of decision variables and the quantification of goal attainment levels, goal preferences, and the relationships between forest residue treatment methods and managerial goals.

Keywords: Forest residues, computer programs.

Much attention has been focused on the problems associated with the generation and disposition of forest residues in the Pacific Coast States. Concerns range from:

a. The volume of logging residues left following harvesting (Howard 1973), to

b. The economic and environmental impacts associated with a variety of residue reduction treatments (Bare and Jayne 1973, Cramer 1974), to

c. The feasibility of using logging and mill residues as potential sources of electrical energy generation and as raw material for forest products (Grantham et al. 1974).

The central objective of many of these and other studies has been the analysis of alternative methods of residue reduction. This paper focuses on the problem of examining selected economic and environmental impacts associated with alternative residue treatment methods; the specific objective is to demonstrate the potential use of goal programing.

Because of the dynamic nature of a forest ecosystem, almost any action taken to modify or dispose of forest residues has an impact or influence on other forest resources. Thus, the forest manager must evaluate the tradeoffs between residue reduction alternatives and their subsequent impacts on the environment, other forest resources, and people. Unfortunately, it is usually difficult or impossible for a manager to adequately evaluate these tradeoffs because the benefits and the undesirable effects of alternative treatments are seldom understood, the relationships between residues and other forest resources are not well documented, and few of the above consequences can be well quantified. The complexity and natural variability inherent in residues-related problems also add to the difficulty of evaluating treatment alternatives.

Pierovich and Smith (1973) have proposed a general framework for decisionmaking, concerning the evaluation of residue reduction alternatives. They emphasize that any operational framework should allow a decisionmaker to analyze treatment alternatives within a multiple use context.

The objective of this paper is to explore the utility of goal programing as an operational decisionmaking tool for analyzing selected forest residue treatment alternatives within the multiple use framework proposed by Pierovich and Smith. Since goal formulation is an integral part of multiple use management, any operational tool must have the flexibility to accommodate diverse sets of objectives. Goal programing provides this capability to resource managers.

Following an introduction to, and discussion of, the goal programing technique, an illustrative residue treatment application is presented. The paper concludes with a summary and statement of recommendations for future work in this area.

INTRODUCTION TO GOAL PROGRAMING

Goal programing is a variation of linear programing. As such, it retains the same basic assumptions of proportionality, additivity, and divisibility. Also, goal programing, like linear programing, is a deterministic decisionmaking technique. However, goal programing differs in having the capability of incorporating multiple objectives. This is accomplished by establishing a set of goals to be attained. Goal programing then seeks an allocation of resources which minimizes the sum of the deviations from these specified goals.

A preference structure for ranking and/or weighting goals is also incorporated within the goal programing procedure. This allows a decisionmaker to explicitly specify the importance of attaining any particular goal in comparison with any other goals he may be considering. In summary, goal programing translates a multiple objective planning problem into a single objective function problem by focusing on the minimization of deviations from specified goals.

The term "goal programing" was coined by Charnes and Cooper (1961), whose concept of "goal attainment" evolved as a means for solving previously unsolvable linear programing problems. The goal programing literature has expanded rapidly since then. Presently, the texts of Ijiri (1965) and Lee (1972) provide the only complete treatments of the theoretical concepts underlying goal programing.

Use of goal programing within a forest management planning context is also recent. Both Rustagi (1973) and Field (1973) have demonstrated the potential and the limitations in this respect. Lyon[1] has applied goal programing to a hypothetical accounting problem in the forest industry, and Porterfield (1973, 1974) has used goal programing in studying the efficiency of tree improvement programs. Romesburg (1974) has applied goal programing to the scheduling of recreation and wilderness areas. The U.S. Forest Service has published a goal programing user's manual with illustrative examples (U.S. Department of Agriculture Forest Serivce 1974). The manual is intended for those who wish to use Lee's (1972) simplex-based algorithm for solving goal programing problems on a computer. No applications of goal programing to evaluate residue reduction treatment alternatives have been found in the literature.

---

[1] Lyon, Gary. 1974. Applications of goal programming and accounting for control in the forest industry. Unpublished manuscript. Res. Pap., 53 p. Coll. For. Resour., Univ. Wash., Seattle.

The general formulation of a goal programing problem (after Lee) is:

$$\text{Minimize } Z = w_1 d^- + w_2 d^+$$

subject to:

$$Ax + Id^- - Id^+ = b$$

$$Bx \{\leq, =, \geq\} h$$

$$x_j \geq 0 \text{ for all } j = 1, 2, \ldots, n$$

$$d_k^- \geq 0 \text{ for all } k = 1, 2, \ldots, m$$

$$d_k^+ \geq 0 \text{ for all } k = 1, 2, \ldots, m$$

$$d_k^+ \cdot d_k^- = 0 \text{ for all } k = 1, 2, \ldots, m$$

where

w_1, w_2 = (lxm) vectors of priority factors (P_k, $k = 1, 2, \ldots, m$) for ordinal ranking and differential weights ($\alpha_{i,k}$, $i = 1, 2, \ldots, m$; $k = 1, 2, \ldots, m$) for cardinal weighting within a given priority rank. These weighting vectors, therefore, can be expressed as: $w_\ell = (\alpha_{1,k} P_k, \alpha_{2,k} P_k, \ldots, \alpha_{m,k} P_k)$, $\ell = 1, 2$ and $k = 1, 2, \ldots, m$

d^-, d^+ = (mxl) vectors of negative and positive deviational variables representing negative and positive deviations from goals.

b = (mxl) vector of desired goal levels
A = (mxn) matrix of coefficients which relate the technical relationships between decision variables and goals
x = (nxl) vector of decision or choice variables
I = (mxm) identity matrix
B = (rxn) matrix of coefficients which relate the technical relationships between decision variables and constraints
h = (rxl) vector of constraint levels
n = index referring to the number of variables
m= index referring to the number of goals
r = index referring to the number of constraints

Except for the restriction, $d_k^+ \cdot d_k^- = 0$, it is readily apparent that this problem can be solved with the simplex method of linear programing. Since d_k^- and d_k^+ are linearly dependent, the simplex algorithm automatically ensures that the above stated constraint is always satisfied. Therefore, these latter constraints will be ignored in the remainder of this paper.

As formulated above, the problem is to minimize the sum of positive and negative deviations from a set of specified goal levels subject to a set of constraints. Hence, it is assumed that all goals are to be as closely attained as possible. Many times, however, overachievement of a particular goal is an acceptable outcome. In such cases, the positive deviational variable can be deleted from the objective function. In this case, the objective is to minimize the underachievement of a goal by driving the negative deviational variable to zero. However, the positive deviational variable in solution is free to take on any value ≥ 0. If underachievement of a goal is an acceptable outcome, the negative deviational variable is deleted from the objective function. In this case, the objective is to minimize the overachievement of a goal by driving the positive deviational variable to zero. However, the negative deviational variable in solution is free to assume any value ≥ 0. If, as originally stated above, exact achievement is desired, both the positive and negative deviational variables must appear in the objective function.

One of the key features of goal programing is its ability to allow a decisionmaker to ordinally rank goals according to his own preference structure. The effect of this ordinal ranking in the solution process is to force the goal with the highest priority to be satisfied as closely as possible before the next lower ranking goal is considered. Several goals may be assigned the same priority factor. A set of preemptive priority factors is assigned to goals to indicate the desired ranking. These priority factors are defined such that $P_k >>> P_{k+1}$, which implies that a goal ranked at P_k is more important than a goal ranked at P_{k+1}. This relationship among goals holds throughout the entire solution process. In particular, at any point in the computational process, a variable cannot enter the solution and, hence, improve the attainment of a goal at a given priority level at the expense of a goal assigned a higher priority.

In addition to the ranking of goals through the assignment of priority factors, deviational variables within a given priority level may be assigned differential weights. These weights express the relative opportunity cost or regret associated with one unit of unsatisfactory deviation from the goal level (Ijiri 1965). These so-called "coefficients of regret" are assigned to deviational variables associated with a common goal and assigned a common priority factor. The challenging problem is to define these "coefficients of regret." Arbitrary assignments of weights are valid only so long as other decisionmakers agree. In the end, each decisionmaker must pass judgment on the appropriateness of assigned weights and priority factors.

ALGORITHMS FOR GOAL PROGRAMING

The simplex algorithm of linear programing can be used to solve goal programing problems. However, if more than one priority level is involved, the preemptive priority factor must be converted to numerical values to preserve the desired ranking. Field (1973) has suggested a "priority factor algorithm" for determining these numerical values, thus permitting use of the standard simplex algorithm.

Lee (1972) has modified the standard simplex algorithm in such a way that numerical coefficients for the different preemptive priority factors are not required. Instead, his method accepts the ordinal ranking of goals as provided by the decisionmaker. This preference structure is subsequently incorporated into the simplex algorithm by maintaining a matrix of $Z_j - C_j$ values[2/] instead of the customary row vector. Each row of the matrix contains $Z_j - C_j$ values for a particular priority level. At each iteration of the simplex algorithm, the row of the matrix corresponding to the highest priority factor currently being considered is used to determine the column vector entering the solution. Only after a goal is attained "as closely as possible" is the next lowest priority level considered. However, as previously stated, a variable, which may be a candidate for entering the solution, cannot enter if it will be done at the expense of a goal assigned to a higher priority.

In other words, all $Z_j - C_j$'s associated with a column vector must be considered before an entering column vector can be selected. Charnes and Cooper (1961) have suggested a third alternative for including priority factors in a goal programing model. However, since their method increases the size of the problem by adding constraints on deviational variables and because it may not produce the true optimum solution, it will not be further discussed in this paper.

In comparing the first two alternatives presented above, Lee (1972, p. 127) states:

> ...some researchers have used the conventional linear programming package by converting the preemptive priority factors to numerical values. However, the use of linear programming by estimating the numerical values of multiple conflicting goals brings us right back to where we started. Conceptually, goal programming is based on ordinal solution on the basis of priority of goals. Consequently, the use of linear programming... not only defeats the very purpose of the goal programming approach, but also violates the basic rule of goal programming.

[2/] $Z_j - C_j$ is common terminology for the evaluation row of the simplex tableau used to determine the column vector that should enter the basis to minimize the objective function at the fastest rate.

Field (1973) also acknowledges this: "His [Lee's] approach appears to represent the only completely satisfactory means of guaranteeing a desired ordinal ranking." The basic issue, of course, is that as soon as preemptive priorities are converted to numerical values, a cardinal rather than an ordinal measure is adopted, and one goal becomes X-times as important as another.[3/] However, if the preemptive priorities can be correctly converted to numerical values, the solution is unaffected.

Lee's modified simplex procedure was used to solve all goal programing problems presented in this paper. A version of this algorithm, modified to run on the CDC 6400 computer system, was obtained and implemented.[4/] According to Lee (1972), the program has been completely tested and debugged. However, occasional problems were encountered, requiring corrective code. An obvious limitation of Lee's program concerns the maximum size of the problem that can be solved. This results because all matrices are retained in central memory during the computational process. For example, approximately 32,000 decimal words of central memory were required for the illustrative problem presented below. As formulated, this goal programing problem allowed up to 9 priority levels, 40 constraints and/or goals, and 180 variables.

AN EXAMPLE OF GOAL PROGRAMING

The following example is intended to illustrate features of goal programing as applied to a specific multiple use decisionmaking problem; namely, the selection of alternative residue reduction treatments consistent with certain prespecified goals.

The problem involves the selection of an appropriate combination of residue and regeneration treatment alternatives for 10 cutting units located on the western slopes of the Washington Cascade Range, such that certain goals are attained as closely as possible while simultaneously satisfying all constraints. Relevant characteristics of these 10 cutting units are shown in table 1.[5/] Some of these data were extracted from reports describing the current condition of recently logged cutting units on the Skykomish Ranger District of the Mount Baker-Snoqualmie National Forest. Other data were fabricated for this example.

[3/] Technically, Lee's preemptive priority factors imply an infinite value ratio and hence a cardinal relation between two goals. However, his algorithm is conceptually based on an ordinal ranking and yields an ordinal solution.

[4/] This program was obtained from Kenneth Bottoms, a management analyst in the Land Use Planning Group, U.S. Forest Service, Fort Collins, Colo.

[5/] See the last page of this report for conversion factors for metric units.

Table 1--*Description of cutting units requiring treatment*

Cutting unit number	Acreage	Slope	Residue	Elevation	Aspect	Condition of slash[1]
		Percent	*Tons/acre*	*Feet*		
1	15	90	80	1,500	South	Dry
2	10	20	100	1,600	North	Green
3	56	10	80	2,800	Flat	Dry
4	19	25	100	2,500	South	Dry
5	25	90	100	1,900	West	Green
6	2	25	80	3,100	South	Dry
7	70	20	80	3,200	West	Dry
8	49	40	40	4,000	Northwest	Dry
9	20	25	100	3,700	South	Green
10	50	90	80	2,000	Northeast	Dry

[1] Dry = Dry slash without needles.
Green = Green slash with needles.

Four alternative residue reduction treatments and three alternative regeneration treatments were considered. These treatment combinations and their respective cost and success ratios[6] are given in table 2. In addition to these treatment alternatives, two sets of constraints and six sets of goals were included.

Table 2--*Residue-regeneration treatment combinations*[1]

Residue alternatives	Residue, cost/acre	Regeneration alternatives					
		Natural		Hand plant		Aerial seed	
		Cost/acre	Success	Cost/acre	Success	Cost/acre	Success
	- - - *Dollars* - -		*Percent*	*Dollars*	*Percent*	*Dollars*	*Percent*
Do nothing	0	0	20	200	65	15	50
Broadcast burn	80	0	45	110	75	15	65
Machine pile and burn	160	0	55	90	80	15	70
Hand pile and burn	250	0	40	90	70	15	60

[1] Assumptions are (1) machine piling and burning not feasible on cutting units with slopes greater than 35 percent, and (2) success ratios are reduced 20 percent for cutting units over 3,000 feet in elevation on southern exposures.

---

[6] Success ratios measure the chance of achieving a fully stocked stand within 3 years of the initial residue-regeneration treatment.

CONSTRAINTS

The first set of constraints specifies that each of the 10 cutting units be completely treated by one or more of the above listed treatment alternatives. The second set specifies that machine piling and burning is not feasible on cutting units with slopes over 35 percent.

GOALS

Six types of goals are included in the example. These are:

a. An annual residue budget goal
b. An annual regeneration budget goal
c. A success ratio goal for each unit following stand establishment
d. A rate of spread goal for each unit following treatment
e. A particulate matter goal associated with residue burning
f. A set of goals for soil loss resulting from each residue treatment method.

These goals, along with the constraints and the various treatment alternatives, are transformed into a goal programing framework as follows.

PROBLEM FORMULATION

Let x_j be the proportion of a cutting unit subjected to one of the feasible residue-regeneration treatment combinations. For clarity, these treatment combinations are listed and numbered in table 3.

Table 3--*List of possible residue-regeneration alternatives*

Treatment combination number	Description of combination	
	Residue treatment	Regeneration treatment
1	Do nothing	Natural
2	Do nothing	Hand plant
3	Do nothing	Aerial seed
4	Broadcast burn	Natural
5	Broadcast burn	Hand plant
6	Broadcast burn	Aerial seed
7	Machine pile and burn	Natural
8	Machine pile and burn	Hand plant
9	Machine pile and burn	Aerial seed
10	Hand pile and burn	Natural
11	Hand pile and burn	Hand plant
12	Hand pile and burn	Aerial seed

Since a total of 12 treatment combinations exists for each of the 10 cutting units, the problem involves a maximum of 120 variables. However, because machine piling and burning is not a feasible alternative on cutting units 1, 5, 8, and 10, due to the maximum slope constraint, only 108 variables actually are needed.

In addition to these 108 choice variables, the negative and positive deviational variables must also be considered. For example, variable x_{33} represents the proportion of the third cutting unit to be treated using hand piling and burning as the residue treatment and aerial seeding as the regeneration method.

The constraint set for the problem can now be expressed as shown in equations 1-10:

$$\sum_{j=s}^{t} x_j = 1 \qquad \begin{array}{l} t = 9,\ 21,\ 33,\ 45,\ 54,\ 66,\ 78,\ 87,\ 99,\ 108 \\ s = 1,\ 10,\ 22,\ 34,\ 46,\ 55,\ 67,\ 79,\ 88,\ 100 \end{array} \qquad (1\text{-}10)$$

Goals to be included in the problem have been listed. The first goal, the annual residue treatment budget, can be written as:

$$\sum_{j=1}^{108} a_{1,j}\, x_j + d_1^- - d_1^+ = b_1 \qquad (11)$$

The $a_{1,j}$ coefficients represent the total cost of treating the residue on a cutting unit using one of the feasible treatment alternatives. For example, consider coefficient $a_{1,28}$ = \$8,960. This is the total cost of treating the residue on cutting unit 3 (56 acres) by machine piling and burning at a cost of \$160 per acre. The two deviational variables in equation 11 reflect the underachievement or overachievement of a given residue budget goal (b_1). The residue budget goal presented here is merely a target level which a land manager believes is a realistic cost for accomplishing a job. This is also true for the regeneration budget goal.

The annual regeneration treatment budget can be expressed as:

$$\sum_{j=1}^{108} a_{2,j}\, x_j + d_2^- - d_2^+ = b_2 \qquad (12)$$

The $a_{2,j}$ coefficients represent the total cost of regenerating the cutting unit using one of the feasible alternatives. Consider coefficient $a_{2,18}$ = \$150. This is the total cost of aerial seeding the second cutting unit (10 acres) at a cost of \$15 per acre following machine piling and burning of the residue. The deviational variables in equation 12 represent the underachievement or overachievement of a given regeneration budget goal (b_2).

The third set of goals (i.e., goals 3-12) concerns the success ratio for newly established stands. With data displayed in table 2, these goals are formulated as:

$$\sum_{j} a_{k,j} x_j + d_k^- - d_k^+ = b_k, \text{ for all } k = 3, 4, \ldots, 12 \qquad (13\text{-}22)$$

The index of summation (j) in the above goals is as previously defined in equations 1-10 . For example, for the fourth cutting unit, the goal is:

$$\sum_{j=34}^{45} a_{6,j} x_j + d_6^- - d_6^+ = b_6$$

The $a_{k,j}$ coefficients represent the success ratio for newly established stands and are as listed in table 2. The b_k terms represent the success ratio goals for each of the 10 cutting units.

The fourth set of goals (i.e., goals 13-22) concerns the potential rate of spread of the fuels left on the cutting unit following the selected residue treatment. These goals are expressed as:

$$\sum_{j} a_{k,j} x_j + d_k^- - d_k^+ = b_k, \text{ for all } k = 13, 14, \ldots, 22 \qquad (23\text{-}32)$$

The index of summation (j) is as defined above. The $a_{k,j}$ coefficients in equations 23-32 represent the potential rate of spread of the perimeter of a fire in chains per hour. These coefficients were estimated as a function of the slope of each cutting unit, the feasible residue treatment alternatives, and the condition of the slash. Because this type of information was not readily available, it was necessary to use postulated values and relationships. Consequently, base line rates of spread were assumed for slopes of 10-30 percent. These figures were doubled for slopes of 31-60 percent and redoubled for slopes of 61-90 percent.[7/] Table 4 contains the resulting assumed values. The rates of spread identified with each feasible residue treatment on each cutting unit were computed using these values--for example, $a_{14,10} = 15$. Thus, if the green slash on cutting unit 2 is left untreated, a potential rate of spread of 15 chains per hour is expected. The b_i values for equations 23-32 represent the rate of spread goals specified for each cutting unit.

[7/] Other factors likely influencing the rate of spread include solar radiation, moisture content, temperature, and size, shape, and distribution of the residues. However, additional experimentation and analysis are needed before these and other factors can be incorporated into any comprehensive land management decisionmaking process.

Table 4--*Assumed potential rates of spread (perimeter increase) affected by slope, residue treatment method, and condition of slash*

(In chains per hour)

Residue treatment	Percent slope		
	10-30	31-60	61-90
No treatment:			
Dry slash	22.5	45	90
Green slash	15	30	60
Broadcast burn	2	4	8
Machine pile and burn	1	2	([1])
Hand pile and burn	3	6	12

[1] Not considered feasible.

The fifth set of goals to be formulated (i. e., goals 23-26) concerns the particulate matter released into the atmosphere as a result of burning. For this example, it was assumed that the 10 cutting units were clustered into 4 groups. Further, it was assumed that it was advantageous to burn residues on four different occasions. Cluster one contained cutting units 1-3, cluster two contained cutting units 4 and 5, cluster three contained cutting units 6-8, and cluster four contained cutting units 9 and 10. The particulate matter goals are expressed as:

$$\sum_{j=1}^{33} a_{23,j} x_j + d_{23}^- - d_{23}^+ = b_{23} \tag{33}$$

$$\sum_{j=34}^{54} a_{24,j} x_j + d_{24}^- - d_{24}^+ = b_{24} \tag{34}$$

$$\sum_{j=55}^{87} a_{25,j} x_j + d_{25}^- - d_{25}^+ = b_{25} \tag{35}$$

$$\sum_{j=88}^{108} a_{26,j} x_j + d_{26}^- - d_{26}^+ = b_{26} \tag{36}$$

The $a_{k,j}$ coefficients in equations 33-36 represent hundreds of pounds of particulate matter released into the atmosphere as a result of burning residue on a specified cutting unit. The total pounds of particulate generated from broadcast and pile burning were computed by multiplying the amount of residue on each cutting unit as reported in table 1 by the conversion coefficients shown in table 5. These coefficients are only rough approximations and are used here for illustrative purposes only. The resulting coefficients for each of the 10 cutting units were computed using these data. For example, coefficient $a_{23,27}$ = 268.8 pounds of particulate (hundreds of pounds). Thus, if the third cutting unit is completely broadcast burned, a total of 26,880 pounds of particulate will be emitted into the atmosphere (i.e., 80 tons/acre X 56 acres X 6 pounds of particulate/ton). The b_k values ($k = 23, 24, \ldots, 26$) for equations 33-36 represent the particulate level goals for clusters of cutting units which will be treated simultaneously. The basic assumption in these equations is the additive effect realized by burning several cutting units. However, this assumption is likely not valid and will be discussed later.

Table 5--*Assumed amount of particulate matter generated for each residue treatment method and condition of slash*

(Pounds per ton)

Residue treatment	Dry slash	Green slash
Do nothing	0	0
Broadcast burn	6	24
Machine pile and burn	4	17
Hand pile and burn	4	17

The sixth and final set of goals (i.e., goals 27-30) concerns the assumed soil loss generated from each residue treatment method. These losses are considered to be only short term (i.e., 3 years or less). This set of goals is formulated as:

$$\sum_j a_{k,j} x_j + d_k^- - d_k^+ = b_k, \text{ for all } k = 27, 28, 29, 30 \qquad (37\text{-}40)$$

The index of summation (j) is as previously defined in equations 33-36 since the effects of soil loss are assumed additive for each cluster of cutting units as it is treated. The $a_{k,j}$ coefficients in equations 37-40 represent the soil loss generated on each cutting unit after a specific residue treatment. These coefficients were obtained by multiplying the number of acres on each cutting unit as reported in table 1, by the conversion coefficients shown in table 6. These conversion coefficients, like the particulate conversion coefficients, are approximations and used only for illustrative purposes. Soil loss was estimated for each residue treatment for cutting units with slopes of 31-60 percent. These estimates were reduced by 10 percent for slopes of 10-30 percent but increased by 15 percent for slopes of 61-90 percent. Thus, if cutting unit 1 is broadcast burned, a total of 7.545 tons of soil will be lost over a 3-year period (i.e., 15 acres X 0.503 ton/acre). The b_k values (k = 27, 28, 29, 30) for equations 37-40 represent the soil loss goals for the cutting units treated together.

Table 6--*Assumed soil loss generated by residue treatment method for a given slope class*

(Tons per acre)

Residue treatment	Percent slope		
	10-30	31-60	61-90
No treatment	0.338	0.375	0.431
Broadcast burn	.394	.438	.503
Machine pile and burn	.422	.469	([1])
Hand pile and burn	.373	.414	.476

[1] Not considered feasible.

RESULTS OF TRIAL RUNS

To demonstrate the sensitivity of the optimal solution under varying goal priority structures, four trial runs were conducted. The goal levels, deviational variables, priority factors, and differential weights assumed in these trial runs are given in table 7.

The first trial run involved 108 decision variables, 30 positive deviational variables, and 40 negative deviational variables, for a total of 178 variables. (Note that a negative deviational variable was associated with equations 1-10.) A total of 40 rows (10 constraints and 30 goals) was also involved.

In the first trial run, each goal was given a priority of P_1 and a differential weight of 1. Either or both negative and positive deviations from their corresponding right-hand side values were allowed for each goal in each of the trial runs. Both negative and positive deviations from residue and regeneration budget goals were specified in the objective function, indicating that exact attainment of each goal was desired. Recall that the residue and regeneration budget goals referred to here are merely target costs which a land manager would consider realistic to accomplish a job. The positive deviational variables for the regeneration success goals were omitted from the objective function, denoting that overattainment was acceptable. Similarly, the negative deviational variables for the rate of spread, particulate emission, and soil loss goals were omitted from the objective function, indicating that underachievement was acceptable. The goal levels are shown in table 7.

Table 7--*Priority structure of goals for trial runs*

Goal number	Goal description	Goal level	Priority of deviational variables[1]							
			Run 1		Run 2		Run 3		Run 4	
			d_k^-	d_k^+	d_k^-	d_k^+	d_k^-	d_k^+	d_k^-	d_k^+
1	Residue budget (dollars)	50,000	P_1	P_1	P_1	P_1	P_3	P_3	P_3	P_3
2	Regeneration budget (dollars)	20,000	P_1	P_1	P_1	P_1	P_3	P_3	P_3	P_3
	Regeneration success (percent):									
3	Unit 1	75	P_1		P_1		P_2		P_1	
4	Unit 2	75	P_1		P_1		P_2		P_1	
5	Unit 3	75	P_1		P_1		P_2		P_1	
6	Unit 4	75	P_1		[2]0.25 P_1		P_2		P_1	
7	Unit 5	75	P_1		P_1		P_2		P_1	
8	Unit 6	75	P_1		P_1		P_2		P_1	
9	Unit 7	75	P_1		P_1		P_2		P_1	
10	Unit 8	75	P_1		P_1		P_2		P_1	
11	Unit 9	75	P_1		P_1		P_2		P_1	
12	Unit 10	75	P_1		P_1		P_2		P_1	
	Rate of spread (chains):									
13	Unit 1	0		P_1		P_1		P_2		P_2
14	Unit 2	0		P_1		P_1		P_2		P_2
15	Unit 3	0		P_1		P_1		P_2		P_2
16	Unit 4	0		P_1		P_1		P_2		P_2
17	Unit 5	0		P_1		P_1		P_2		P_2
18	Unit 6	0		P_1		P_1		P_2		P_2
19	Unit 7	0		P_1		P_1		P_2		P_2
20	Unit 8	0		P_1		P_1		P_2		P_2
21	Unit 9	0		P_1		P_1		P_2		P_2
22	Unit 10	0		P_1		[2]4P_1		P_2		P_2
	Particulate (pounds):									
23	Units 1-3	50,000		P_1		P_1		P_1		P_5
24	Units 4-5	60,000		P_1		P_1		P_1		P_5
25	Units 6-8	40,000		P_1		P_1		P_1		P_5
26	Units 9-10	60,000		P_1		P_1		P_1		P_5
	Soil loss (tons):									
27	Units 1-3	32		P_1		P_1		P_1		P_4
28	Units 4-5	18		P_1		P_1		P_1		P_4
29	Units 6-8	47		P_1		P_1		P_1		P_4
30	Units 9-10	30		P_1		P_1		P_1		P_4

[1] The negative and positive deviational variables, d_k^- and d_k^+, represent the negative and positive deviations from each goal where the subscript k is the index for each goal number.

[2] Each priority has a differential weight of 1 associated with it except as shown here.

The optimal prescription of treatments for trial run 1 is reported in table 8. The corresponding values of the deviational variables are shown in table 9. Observe in table 8 that no single residue or regeneration treatment is prescribed for all cutting units. One apparently surprising result is that, although broadcast burning is only used sparingly, machine piling and burning is prescribed for each of the six cutting units where it is a feasible alternative. However, an examination of the goals for this trial run indicates that this is exactly what should occur.

Let's consider each goal separately to see why this is true. Goal number 1 is to meet as closely as possible the residue budget goal which would be specified by a land manager as a realistic target. Since "no treatment" has no associated costs, treatment selection should only be from those alternatives which do have costs. Broadcast burning all 316 acres at a cost of $80 per acre would utilize only $25,280 of the $50,000 residue budget. Therefore, it is reasonable that more costly residue treatments likely would have been prescribed on some of the cutting units. A reexamination of table 2 shows that the regeneration success ratios for machine piling and burning dominate those for broadcast burning as well as hand piling and burning. Similarly, machine piling and burning results in the lowest potential rates of spread (table 4).

Table 8--*Optimal treatments for trial run 1. Equal priorities and weights*

Cutting unit number	Treatment combination number	Treatment description	Proportion of unit
1	5	Broadcast burn, hand plant	1.000
2	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
3	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
4	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
5	5	Broadcast burn, hand plant	.566
	11	Hand pile and burn, hand plant	.434
6	8	Machine pile and burn, hand plant	1.000
7	9	Machine pile and burn, aerial seed	1.000
8	11	Hand pile and burn, hand plant	1.000
9	8	Machine pile and burn, hand plant	1.000
10	5	Broadcast burn, hand plant	.631
	6	Broadcast burn, aerial seed	.324
	11	Hand pile and burn, hand plant	.045

Table 9--*Goal achievement results*

Goal number	Goal description	Underachievement (d_k^-)[1]				Overachievement (d_k^+)[1]			
		Trial run number				Trial run number			
		1	2	3	4	1	2	3	4
1	Residue budget (dollars)	0	0	0	10,560.00	0	0	5,541.43	0
2	Regeneration budget (dollars)	0	0	0	0	0	0	17,312.57	5,407.50
	Regeneration success (percent):								
3	Unit 1	0	0	0	0	0	0	0	0
4	Unit 2	0	0	0	0	0	0	0	0
5	Unit 3	0	0	5.95	0	0	0	0	0
6	Uint 4	0	5.00	10.00	0	0	0	0	0
7	Unit 5	2.17	2.17	6.43	0	0	0	0	0
8	Unit 6	11.00	11.00	11.00	11.00	0	0	0	0
9	Unit 7	5.00	5.61	5.49	0	0	0	0	0
10	Unit 8	5.00	5.00	5.00	0	0	0	0	0
11	Unit 9	11.00	11.00	23.00	11.00	0	0	0	0
12	Unit 10	3.47	1.84	6.24	0	0	0	0	0
	Rate of spread (chains):								
13	Unit 1	0	0	0	0	8.00	8.00	8.00	8.00
14	Unit 2	0	0	0	0	1.00	1.00	2.00	1.00
15	Unit 3	0	0	0	0	1.00	1.00	6.71	1.00
16	Unit 4	0	0	0	0	1.00	1.00	22.50	1.00
17	Unit 5	0	0	0	0	9.74	9.74	25.74	8.00
18	Unit 6	0	0	0	0	1.00	1.00	1.00	1.00
19	Unit 7	0	0	0	0	1.00	1.12	4.91	1.00
20	Unit 8	0	0	0	0	6.00	6.00	6.00	4.00
21	Unit 9	0	0	0	0	1.00	1.00	15.00	1.00
22	Unit 10	0	0	0	0	8.18	8.00	31.41	8.00
	Particulate (pounds):								
23	Units 1-3	78.8	78.8	42.9	78.8	0	0	0	0
24	Units 4-5	0	0	296.6	0	0	0	0	76.0
25	Units 6-8	91.2	91.2	113.1	52.0	0	0	0	0
26	Units 9-10	23.6	20.0	479.8	20.0	0	0	0	0
	Soil loss (tons):								
27	Units 1-3	0	0	0	0	3.40	3.40	0	3.40
28	Units 4-5	0	0	0	0	2.30	2.30	0	2.59
29	Units 6-8	0	0	0	0	3.67	3.46	0	4.85
30	Units 9-10	0	0	0	0	3.53	3.59	0	3.59

[1] The negative and positive deviational variables, d_k^- and d_k^+, represent the negative and positive deviations
each goal where the subscript k is the index for each goal number.

The particulate matter resulting from both machine piling and burning and hand piling and burning is identical, and both produce less particulate matter than does broadcast burning (table 5). The only case where machine piling and burning is not the preferred treatment is when soil loss is considered (table 6). In this instance, hand piling and burning and broadcast burning are the preferred treatments. However, the difference between treatments is not enough to offset the overall superiority of machine piling and burning when measured in terms of the other goals.

Another result revealed in table 8 is the prescription of multiple treatments on a particular cutting unit. Fractionalization is not desirable but is unavoidable if goal programing is used to solve the stated problem. While this may detract somewhat from the practical usefulness of goal programing, it still permits the use of the technique as a planning tool to evaluate the impacts of various residue treatments.

Table 9 displays the results of trial run 1 in terms of goal attainment. The results show that all goals cannot be achieved if a single priority is specified and all differential weights are equal to 1. In particular, the regeneration success goals for cutting units 5-10 are underachieved. Also, as expected, none of the rate-of-spread goals are achieved. However, the minimum possible rates of spread are achieved for all but cutting units 5, 8, and 10. The particulate emission goals, set at hypothetical maximum permissible levels, were met or exceeded in all cases (i. e., there was underachievement of each of the goal levels). However, none of the soil loss goals were held within their hypothetical maximum permissible levels. Lastly, the residue and regeneration budgets are achieved exactly, thus resulting in completely utilizing both budgets.

Whether the goal achievements and the prescribed treatments are acceptable is a matter of conjecture. To examine this question further, it was decided to evaluate the sensitivity of the optimal solution to changes in differential weights associated with selected deviational variables in the objective function. Accordingly, a second trial run was formulated. In this run, it was assumed that, if possible, the rate of spread on cutting unit 10 should be reduced to 8 chains per hour--the minimum for the unit. In an effort to achieve this rate-of-spread goal, a differential weight of 4 was assigned to the positive deviational variable associated with goal number 22. Further, a differential weight of 0.25 was assigned to the negative deviational variable associated with the regeneration success ratio goal for the fourth cutting unit. Thus, attainment of the 75-percent regeneration success ratio on the fourth cutting unit was only one-quarter as important as was the attainment on the other nine units. All other differential weights were set to unity, and all goals were given equal priority.

The goal structure for trial run 2 is summarized in table 7, and the optimal treatment prescriptions are shown in table 10. The results in table 10 are very similar to those of the first trial run. The goal attainment for run 2 is shown in table 9. Of particular interest are the goal achievement levels of the two goals whose corresponding differential weights were modified. As seen in table 9, the regeneration success on cutting unit 4 was underachieved by 5 percent after the 0.25 differential weight was assigned.

Table 10--*Optimal treatments for trial run 2. Equal priorities and differential weights with two exceptions: (1) the differential weight for the negative deviational variable of goal 6 is 0.25; and (2) the differential weight for the positive deviational variable for goal 22 is 4*

Cutting unit number	Treatment combination number	Treatment description	Proportion of unit
1	5	Broadcast burn, hand plant	1.000
2	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
3	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
4	9	Machine pile and burn, aerial seed	1.000
5	5	Broadcast burn, hand plant	.566
	11	Hand pile and burn, hand plant	.434
6	8	Machine pile and burn, hand plant	1.000
7	9	Machine pile and burn, aerial seed	.939
	12	Hand pile and burn, aerial seed	.061
8	11	Hand pile and burn, hand plant	1.000
9	8	Machine pile and burn, hand plant	1.000
10	5	Broadcast burn, hand plant	.816
	6	Broadcast burn, aerial seed	.184

However, unexpectedly, the regeneration success on cutting unit 7 was also slightly worse than in trial run 1. Also, the rate of spread on cutting unit 10 was reduced to a minimum of 8 chains per hour after the new differential weight of 4 was assigned. However, the rate of spread on cutting unit 7 was slightly higher than in run 1. Note that the new differential weights also slightly affected the attainment of goals 12, 26, 29, and 30.

It is clear that, in this problem formulation, the use of the two differential weights does not significantly affect either the prescribed treatments or the goal attainment levels. This does not come as a surprise because a sensitivity analysis of the optimal solution to run 1 revealed the insensitivity of the problem to perturbations in these two differential weights, as well as the others. However, the second trial run was formulated to demonstrate this property.

In addition to allowing the inclusion of differential weights within a given priority level, goal programing is also capable of solving problems involving more than one priority. To demonstrate this powerful feature, two additional trial runs are presented.

For trial run 3, highest priority was assigned to the two environmental goals (i. e., soil loss and particulate emission). Second highest priority was assigned to goals for rate of spread and regeneration success, and lowest priority was assigned to the two budget goals. The optimal treatment prescriptions for trial run 3 are presented in table 11. As expected, in an effort to achieve the two environmental goals, no residue treatment was prescribed for a portion of six of the cutting units. Also, machine piling and burning was prescribed for only one unit. Another difference between runs 1 and 2 and run 3 was that hand planting was prescribed for all cutting units.

Table 11--*Optimal treatments for trial run 3. Three priorities*

Cutting unit number	Treatment combination number	Treatment description	Proportion of unit
1	5	Broadcast burn, hand plant	1.000
2	5	Broadcast burn, hand plant	1.000
3	2	No treatment, hand plant	.190
	11	Hand pile and burn, hand plant	.810
4	2	No treatment, hand plant	1.000
5	2	No treatment, hand plant	.286
	11	Hand pile and burn, hand plant	.714
6	8	Machine pile and burn, hand plant	1.000
7	2	No treatment, hand plant	.098
	11	Hand pile and burn, hand plant	.902
8	11	Hand pile and burn, hand plant	1.000
9	2	No treatment, hand plant	1.000
10	2	No treatment, hand plant	.249
	11	Hand pile and burn, hand plant	.751

The most interesting difference between this run and the previous two is seen in table 9. Recalling that highest priority was assigned to goals 23-30, we see that the soil loss goals were achieved and that a substantial improvement over the hypothetical maximum tolerable particulate emission was realized. These environmental goals were achieved at the expense of the lower priority goals. For instance, the goal attainment levels for priority-two goals were worse for a majority of the goals, with only one goal showing any improvement. Last, the two priority-three, budget goals for residue and regeneration were both overachieved. This implies that the prescribed optimal treatments cannot be undertaken unless additional funds are secured.

Trial run 3 demonstrates the importance of goal priority specification and its effect on the recommended course of action. To further illustrate this point, a fourth trial run was made.

Trial run 4 involved five priority levels. The goals and their associated goal levels are shown in table 7. The goals for trial run 4 by priority were: (1) regeneration success, (2) rate of spread, (3) budget, (4) soil loss, and (5) particulate emissions. As in trial run 3, all differential weights within a given priority were set equal to 1.

The optimal treatment prescriptions for trial run 4 are displayed in table 12. As expected, machine piling and burning and broadcast burning are the preferred treatments.

The goal attainment results shown in table 9 reveal that all regeneration success goals except those associated with cutting units 6 and 9 are achieved. Note, however, that the maximum possible regeneration success for both units is 64 percent. Thus, it is impossible to achieve the 75-percent success being sought. In effect, then, all priority-one goals are achieved. The second-priority goals (i. e., rate of spread) are also achieved as fully as possible. The residue budget goal is underachieved, resulting in a surplus of funds, while the regeneration budget is overachieved, resulting in an overcommitment of funds. However, there is a net surplus of unallocated funds. The four soil loss goals are overachieved, resulting in more than the theoretical permissible amount of soil loss. Last, three of the particulate emission goals are underachieved, while one is overachieved. Thus, in three of four cases, the prescribed treatments will produce less than the theoretical maximum tolerable level of emissions.

Table 12--*Optimal treatments for trial run 4. Five priorities*

Cutting unit number	Treatment combination number	Treatment description	Proportion of unit
1	5	Broadcast burn, hand pile	1.000
2	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
3	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
4	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
5	5	Broadcast burn, hand plant	1.000
6	8	Machine pile and burn, hand plant	1.000
7	8	Machine pile and burn, hand plant	.500
	9	Machine pile and burn, aerial seed	.500
8	5	Broadcast burn, hand plant	1.000
9	8	Machine pile and burn, hand plant	1.000
10	5	Broadcast burn, hand plant	1.000

CONCLUSIONS AND RECOMMENDATIONS

The principal objective of this paper was to explore the potential of goal programing for evaluating forest residue treatment alternatives. An example was presented to highlight selected aspects of this evaluation.

It is clear that, while goal programing offers considerable promise as an operational decisionmaking tool, it is by no means a panacea for residue treatment selection. Furthermore, the drawbacks discussed below are in no way unique to the evaluation of residue treatment alternatives. In fact, these same drawbacks are common to similar forest management applications of goal programing.

The implications of the divisibility and additivity assumptions of goal programing were demonstrated by the illustrative sample problem. The former assumption permits a cutting unit to be treated by multiple residue and/or regeneration treatments. For instance, in run number 1, two residue and two regeneration treatments were prescribed for cutting unit 10 (table 8). This fractionalization might cause serious problems if an attempt was made to implement the goal programing solution in a real-world environment. Additional study along these lines is warranted.

A possible solution would be to use an integer linear programing algorithm to solve the problem. However, since no integer goal programing algorithm utilizing an ordinal ranking of goals currently is available, this would necessitate assigning a set of numerical preemptive priority factors.[8/] As already discussed, this defeats the very purpose of goal programing.

The implications of the additivity assumption were also highlighted in the illustrative sample problem by the introduction of the particulate matter and soil loss goals. Although it is true that simultaneously burning residue on several units results in a cumulative particulate emission effect, it is probably incorrect to assume that such effects are additive. This also applies to the soil loss goals.

Further, if the cutting units are burned under reasonable atmospheric conditions at different times, there probably would not be any significant cumulative effect. Under these conditions, it may be more appropriate to establish individual emission goals for each cutting unit rather than one cumulative goal for all units. These two drawbacks are also common to linear programs.

A second difficulty encountered in using goal programing lies in goal specification. A decisionmaker or analyst planning to use goal programing must be very precise in specifying goal attainment levels and priorities. Optimal solutions under certain combinations often produce surprising results which at first may seem incorrect. However, it is usually discovered that the goals were either misformulated or inappropriately weighted or ranked. Although the precise quantification of goal attainment levels and priorities is listed here as a drawback, it should also be pointed out that because goal programing can accept this type of information, it is also one of the strong points of the technique.

At the present state of development, it is difficult or impossible to adequately quantify goals, goal attainment levels, or goal preferences. This is especially true if they are interpreted within a multiple use planning context. For example, in his discussion of goals and decisionmaking in the U.S. Forest Service, Alston (1972) states that ". . . priority determination must become an explicit as well as an integral part of the planning activity." Alston also discusses the importance of assigning weights to the various goals. As previously presented, goal programing can accommodate both the ordinal ranking of goals and the cardinal weighting of goals as specified by a decisionmaker. The fact that most managers currently do not explicitly rank or weight goals is not very surpirsing. However, to make maximum use of goal programing, it is clear that this is precisely what must be done.

[8/] According to Lee, an integer goal programing algorithm utilizing ordinal ranking procedure has recently been developed.

Another problem associated with using goal programing concerns the dearth of information needed to adequately estimate coefficients. While this difficulty is common to most programing analyses, it is one which seriously limits operational usefulness. Conversely, however, the use of programing techniques graphically points out existing data gaps. Not only does this provide management with an assessment of its current level of knowledge and understanding, it also accommodates an evaluation of the degree of reliability to be associated with the results of the analysis.

Last, concern over computational matters encountered in using goal programing for residue treatment evaluation deserves additional comment. Because goal programing permits the inclusion of a variety of functionals, it is sometimes difficult to decide on the most appropriate form for any given problem. This was illustrated in the sample problem presented earlier. Both the analyst and the decisionmaker must be very careful in exploring the implications of alternative functionals before committing themselves.

A second computational limitation is that Lee's computer program can accommodate only relatively small problems. For example, in the sample formulation only 15 to 20 cutting units could be included in an analysis of residue treatment alternatives. Of course, Lee's algorithm could be reprogramed to handle larger problems or use could be made of regular linear programing computer packages which easily accommodate much larger problems. However, in this latter case, an ordinal ranking of goals can not be accommodated.

The principal recommendation of this paper is that goal programing be further evaluated in a real-life decisionmaking environment. Only in this way can a more realistic decision be made concerning the usefulness of the technique for evaluating forest residue reduction treatments. Specifically, it is recommended that the next step be to work with the staff of a National Forest to structure a real-life test of the model illustrated in this paper. A necessary prerequisite of such an application will be a modification of Lee's computer program to accommodate larger problems or the use of a standard linear programing package. Additional investigation is required before a choice between these two can be recommended.

Goal programing is one of the few mathematical programing techniques which offer considerable promise as an aid for making operational decisions in a multiple goal context. By its very nature, it appears compatible with the explicit or implicit decisionmaking procedure utilized by forest managers. Thus, continued research into the applicability of the technique is recommended at this time.

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CONVERSION FACTORS

1 foot = 0.3048 meter

1 surveyor's chain (66 feet) = 20.1168 meters

1 acre = 0.4046856 hectare

1 pound = 0.453592 kilogram

1 short ton (2,000 pounds) = 0.907184 metric ton

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ESTIMATING
WO INDIRECT LOGGING COSTS
CAUSED BY
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ABSTRACT

In forest areas where high soil erosion potential exists, a comparative yarding cost estimate, including the indirect costs determined by methods proposed here, shows that the total cost of using "advanced" logging methods may be less than that of "traditional" systems.

INTRODUCTION

The harvesting of timber in environmentally sensitive areas of the Pacific Northwest has been opposed in recent years by many individuals interested in protecting our forest environment. These conservationists hold a popular concept that timber harvest causes severe damage to soils, stream water quality, reforestation, and wildlife habitat. These fears are not irrational because severe watershed damage has occurred, but a disregard for good forest environment management is not a general practice in the forest industry. Basically, it is not the temporary elimination of trees in a timber harvest operation that precipitates watershed damage. Severe environmental damage to watersheds is usually the result of improper techniques used in the removal of the harvest trees.

Dyrness (1967, 1972), Wooldridge (1960), Ruth (1967), and Klock (1975) have shown that the forest industry presently has proven methods of removing the felled trees from the forest with a minimum of impact on the soil and vegetation resource. In environmentally sensitive areas in Northwest forest lands, proper logging procedures may require the use of an "advanced" logging system such as skyline or helicopter (Klock 1975). Generally the system involves the aerial movement of the felled tree to a landing deck. Since more energy is expended in the aerial movement of logs, the direct yarding cost can be expected to be higher than with "traditional" logging systems (tractor and jammers). However, the expenditure of additional energy for yarding may be offset by less energy requirements for road construction, road maintenance, and log transportation.

Esthetics alone does not justify the increased cost of advanced logging systems. An approach to determining the operating cost differential would be to estimate the potential forest environment damage that might occur on an identifiable timber sale for each available system of removing the fallen trees. The monetary value of these potential damages could be charged to each logging system as an indirect cost assessment on the volume of timber removed. However, this method should not be used to justify destroying nonrenewable natural resources because monetary value estimates may be attached to them.

Indirect costs of timber removal are difficult to determine and are therefore rarely estimated.[1/] This paper will not attempt to identify all indirect logging costs, nor will it show a complete economic analysis of those that are identified. Because the most apparent indirect costs are those associated with erosion, these are ones I will discuss.

Once eroded soil material has been transported off forest slopes and enters a stream system, the effects can be measured in terms of:

1. loss of site productivity (both trees and understory vegetation),
2. sedimentation,
3. water quality (domestic, esthetic, and irrigational),
4. fisheries habitat loss, and
5. increased need for erosion seeding and control.

By developing unit cost figures for these effects, it may be possible to show that soil loss by erosion can be a long-term, indirect cost. If the erosion costs can be determined, they should be added to the direct operational costs when systems of log removal for a particular forest site are evaluated.

[1/] Don Boyer. Letter to the record: watershed protection and management damage to watershed values. May 13, 1971. USDA Forest Service, Region 6, Portland, Oreg.

BACKGROUND

Hypothetical indirect cost estimates from soil loss could be developed for most forest areas. To be useful, the degree of potential erosion which may be generated by each proposed logging system must be estimated. This is not an easy task, and more extensive research is needed to predict the erosion potential in many areas.

In the postfire salvage logging operation described by Klock (1975), the impact on soils and vegetation by five logging systems was evaluated. Both "traditional" and "advanced" systems of tree removal were reported for three watersheds in the Entiat River basin of north-central Washington. This area is characterized by steep and rugged relief where mean slope is about 50 percent and can be categorized as an environmentally sensitive area. The base rock in the study area is Mesozoic granodiorite deeply weathered where exposed. Soils are formed from weathered granodiorite colluvium covered by volcanic ash and pumice. Nearly all forest floor litter within the study area had been destroyed by fire; thus the soil surface was in a more sensitive condition for disturbance by logging. After these soils were disturbed by logging they became highly susceptible to erosion during the high snowmelt period and the high intensity rainstorm described in Klock (1975). Habitat types affected by the vast 1970 wildfire ranged from the *Pinus ponderosa/Purshia/Agropyron* at the lower elevation to *Pseudotsuga menziesii/Calamagrostis rubescens* at higher elevations (Tiedemann and Klock 1973). Snowbrush ceanothus (*Ceanothus velutinus* Dougl.) was predominate in the understory cover.

Volume yields are relatively unknown for the study area, but it appears the undisturbed forest under present management levels could produce in one rotation of approximately 120 years, 6,000 board feet per acre (35 m^3/ha) on the steep upper slopes and up to 15,000 board feet per acre (90 m^3/ha) on the more fertile valley lands. An average volume would be about 8,600 board feet per acre (50 m^3/ha

A replicated greenhouse biomass productivity test (bioassay) of the soils from the slopes of the experimental area reflects the high concentration of available plant nutrients in the immediate soil surface (fig. 1).[2] Removal of

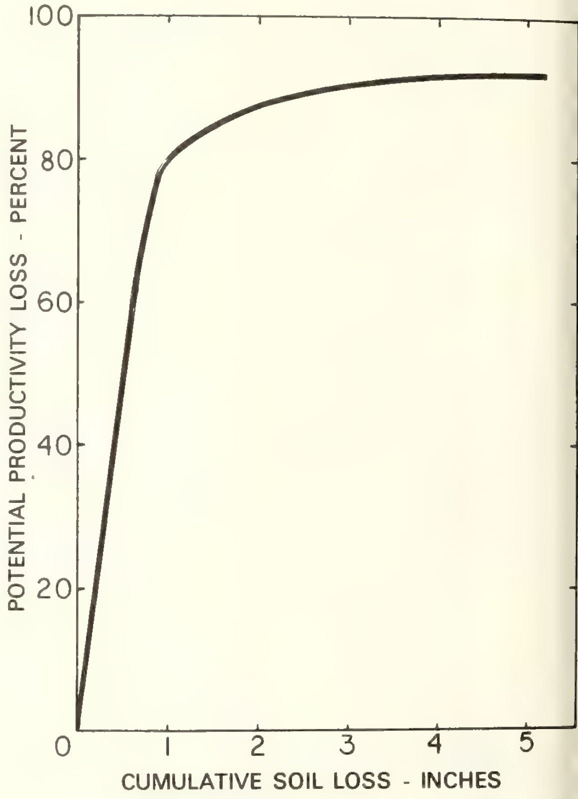

Figure 1.--Potential productivity loss as a function of cumulative surface soil loss.

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[2] G. O. Klock. Unpublished data on file, Pacific Northwest Forest and Range Experiment Station, Wenatchee, Wash.

1.2 inches (3 cm) of topsoil from the effective zone of rooting in the soil profile (1 foot) without consideration for future natural nutrient replacement resulted in an 80.5-percent reduction in the short-term biomass yield. Thus, figure 1 shows that potential forest biomass productivity could be reduced strikingly by increased erosion of topsoil within the experimental area.

METHODS OF ESTIMATING INDIRECT COST

Enough information was available from the study area to test the proposed approach to estimating indirect logging costs caused by accelerated erosion. Indirect costs are identified as onsite and downstream damages.

Onsite Damages

An estimation of the rate of natural nutrient accumulation is one possible approach to determining onsite damages due to biomass productivity loss from an increment of soil displacement by erosion. Plant nutrients of particular interest would be nitrogen, phosphorus, and sulfur. In the study area ecosystem it appears that symbiotic nitrogen fixation and precipitation would not be expected to exceed 5 pounds of nitrogen per acre (5.6 kg/ha) annually (Zavitkovski and Newton 1968, Tiedemann and Helvey 1973). Thus, to return the nitrogen level to a preerosion level by natural processes after serious surface soil loss by erosion may take many years. For example, to accumulate through symbiotic fixation and precipitation enough nitrogen in the surface 1 inch (2.5 cm) to raise the total nitrogen level by 0.1 percent may take several hundred years. The replenishment by natural processes of phosphorus and sulfur lost by erosion could also be expected to require a long period of time. It is obvious that a significant loss of soil nutrients by serious surface erosion, particularly from a soil profile where the major nutrient supply is very close to the surface (fig. 1), could have a major influence in reducing future timber production. It may be possible to calculate differences in productivity and relate this to income at the time of the next rotation harvest. However, with current discount rates of 7 to 10 percent, income differences due to different levels of productivity would be negligible at present prices for a rotation of 120 years. Thus, this approach to determining onsite damage has merit but does not appear feasible under present biologic and economic constraints.

Relevant differences in damage to onsite productivity due to various logging methods need to be evaluated in terms of present values. Another approach to determining differential onsite damage cost might be evaluating the cost of chemical replacements for the lost plant nutrients. Use of logging systems that cause more extensive soil erosion should have a higher indirect cost due to probable reduction in future biomass productivity than systems with a low erosion potential. Indirect cost of probable productivity damage due to soil nitrogen loss can be determined by equation 1.

$$\text{Productivity damage assessment} = \frac{\text{area} \times \text{erosion depth} \times \%\ \text{total soil N} \times \text{A} \times \text{B}}{\text{timber volume assessed}} \qquad (1)$$

A is the fertilizer conversion rate (100 pounds of nitrogen per 100 pounds of fertilizer) and B is the cost of fertilizer plus application (dollars per pound per unit area). The use of ammonium phosphate sulfate for cost calculation purposes should fulfill both the plant phosphorus and sulfur as well as nitrogen requirements and would have a conversion rate of 6.5.

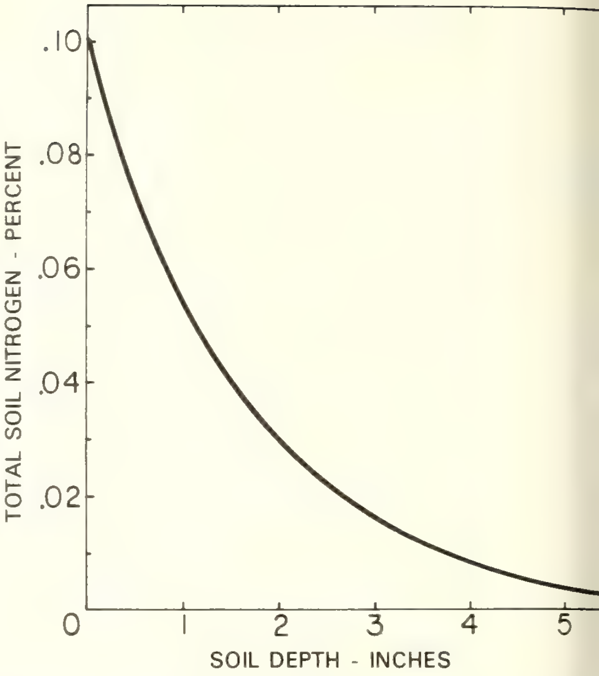

Figure 2.--Representative depth distributi of total soil nitrogen for the study are

A representative soil total nitrogen level distribution as a function of depth within the soil profile for the study area is shown in figure 2. Using these soil nitrogen levels, along with the total nutrient application costs shown in figure 3 (Perkins and others 1971), the dollar assessment per 1,000 board feet for incremental soil loss can be calculated by equation 1 and is shown in figure 4. Thus, 1 inch of soil loss by erosion could result in a productivity damage assessment at present prices of about $13 per 1,000 board feet harvested in

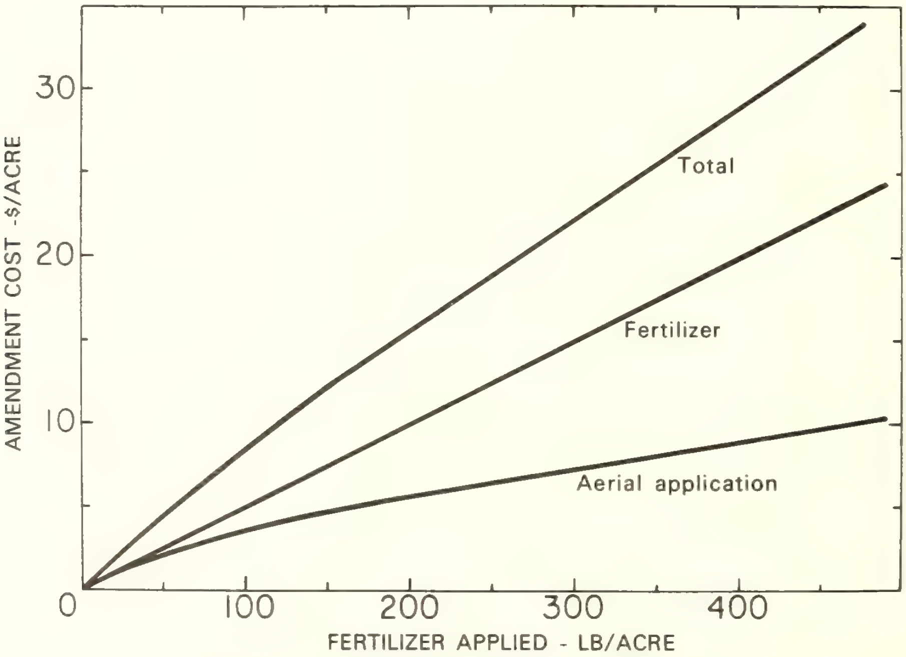

Figure 3.--Amendment application cost for the study area. Fertilizer costs were calculated at $100 per ton and aerial application costs were obtained from a helicopter fertilization program described by Perkins and others (1971).

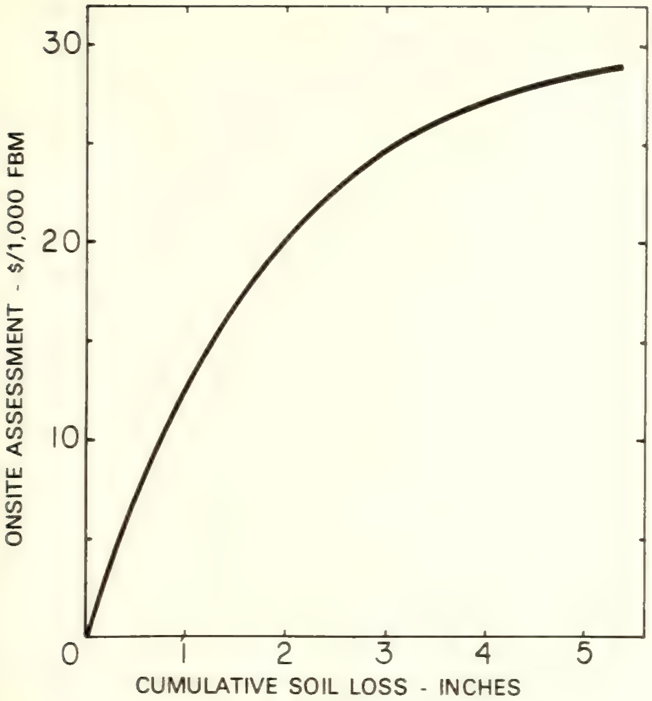

Figure 4.--Indirect logging assessments for possible onsite damage due to cumulative soil loss by accelerated soil erosion after fire.

the study area. This assessment could be larger on a more fertile soil. I believe this cost assessment is very conservative, particularly with respect to the rapidly advancing value of our forest soil resource as well as increasing energy cost for chemical amendments. Although I have used chemical amendments to calculate productivity damage values, their field use in this manner as an alternative for good forest soil management is not recommended.

Downstream Damages

Cost estimates of downstream damages due to erosion from logged areas, such as sedimentation and deterioration of water quality and fisheries habitat, are difficult to determine. These costs must be considered on an individual study basis because the use of water and value of the fisheries vary widely from area to area. Upper values of streambeds for salmon spawning have been estimated to range from $10,000 per acre ($24,700/ha) on Lost Creek, Willamette National Forest, to $3.2 million per acre ($7.9 million/ha) at the Fraser River, British Columbia, Canada.[3] Numbers of salmon spawning in the Entiat River below the study area watersheds appear to be similar to or slightly below those reported for Lost Creek. Deterioration in water quality and damaged salmon spawning beds by soil erosion from the study area are evident in the Entiat River. However, other erosion losses from fire-affected watersheds outside the study area make estimates of damages to fisheries by each system of logging impossible.

The only downstream damages for which cost estimates as a function of soil loss appear to be readily available for assessing against timber harvest in the study area are those due to reservoir sedimentation.

Sediment removal costs are available from reservoir sediment removal projects.

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[3] R. W. Phillips. Fishery resource considerations on western forest lands. Forest-Fisheries Habitat Seminar, Feb. 17, 1970, Reedsport, Oreg.

Cost of sediment removal will range from \$0.25 per cubic yard (\$0.33/m^3) for dredging to as much as \$18.30 (\$24.00/m^3) or more where specific placement of sediment is involved. Since sediment removal costs are not available for the hydroelectric storage reservoirs below the study area, I will assume an approximate average cost of \$4 per cubic yard (\$5.25/m^3) for sediment removal. This average cost may be quite conservative, particularly in areas where the current energy crisis increases the necessity and value of water in reservoir storage.

Equation 2 provides the incremental sedimentation cost.

$$\text{Sedimentation assessment} = \frac{\text{area} \times \text{erosion depth} \times \text{removal cost}}{\text{timber volume assessed}} \qquad (2)$$

Equation 2 shows that an average 1 surface inch of soil loss will create a sedimentation assessment of \$62.53 per 1,000 board feet of saw logs, based on a sediment removal cost of \$4 per cubic yard in the study area.

I have attempted to estimate only costs of erosion due to yarding. Fredriksen (1970) has shown that timber harvest roads in western Oregon can cause an increase in stream load sediment in the first year of up to 12.5 tons per acre. In another study (Klock 1975), I found the combination of cable skidding and tractor yarding resulted in 12 percent more spur roads than did the combination of helicopter and tractor yarding. This increase in roads certainly demonstrates the potentially higher reservoir sedimentation cost of traditional yarding, compared with advanced logging systems.

TOTAL INDIRECT COST

By combining the onsite and downstream damages in terms of costs as a function of soil loss by erosion, I developed a first approximation of the total indirect cost assessment that could be made against the timber harvested within the study area in 1972 (fig. 5).

No exact average depth of soil loss can be measured for the various timber harvest techniques used in the study area. I used a rough estimate of soil loss (Klock 1975) to develop a first approximation of total indirect costs with equations 1 and 2 for comparison of possibly more realistic long-term cost of timber harvest by the various techniques in the study area. The results are shown in table 1.

In table 1 the harvested timber has been assessed some of the indirect costs created by soil erosion in the study area. In this case, several

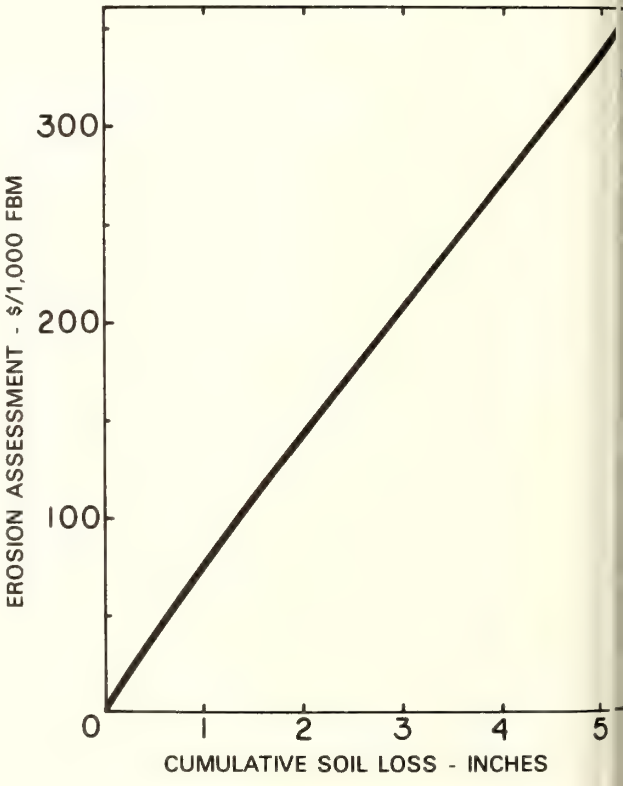

Figure 5.--Total indirect logging assessme for onsite and downstream damages due to cumulative soil loss by accelerated eros after fire.

Table 1--*Some cost estimates of tree removal per 1,000 board feet of merchantable lumber for several yarding systems used in the fire-affected study area*

System	Erosion	Direct cost[1]	Indirect assessment		Total "cost"
			Productivity	Sedimentation	
	Inches	- - - - - - - - - - - -	*Dollars*	- - - - - - - - - - - -	
Tractor, slopes 0-30%	0.20	34.85	3.30	12.50	50.65
Tractor, slopes 30-50%	.80	34.85	10.60	50.00	95.45
Tractor (over snow), slopes 0-40%	.08	38.60	1.50	5.00	45.10
Cable skidding	1.50	35.00	17.00	93.80	145.80
Skyline (Wyssen)	.04	52.73	.80	2.52	56.05
Helicopter	.04	74.98	.80	2.52	78.30

[1] Cost figures are for timber delivered at the mill for each yarding method used in the study area and were provided by Pack-River Lumber Company, Peshastin, Wash.

traditional systems of harvest (tractor over steep, bare ground and cable skidding) were higher in total cost than the advanced systems (skyline and helicopter). Tractor logging over snow appears to have the lowest total unit cost and is considered an environmentally acceptable method of yarding in the study area.

It should again be pointed out that these yarding cost contrasts were developed where (1) the environmentally sensitive study area was in a fire salvage sale, (2) the study area was severely stressed by unpredictable climatic events, (3) once a particle of eroded soil enters a stream system it will be impounded in a reservoir, (4) several assumptions and estimates were used in the models, and (5) other indirect costs such as deterioration of water quality and fish habitat and the detrimental effect of sediment from the road system were not included. These cost comparisons must be considered as first approximations.

Some of the indirect logging cost estimates in table 1 also include erosion damages as the result of fire by itself. Therefore the suggested analyses method used here does cause a relatively small error (up to $2-$3 per 1,000 board feet). This overestimate of the indirect cost caused by insufficient information on erosion levels as a result of fire alone appears most noticeable for advanced logging methods used on steep slopes. Linear programing, as well as other useful tools of economic analysis, was not considered in this approach to estimating indirect cost. However, table 1 basically showed that it may have been more reasonable on a long-term cost basis to harvest with an advanced logging system instead of the cable skidding and tractor systems in some parts of the study area. This observation is reached without determining any cost to deterioration in esthetic values which may also be important in this example.

SUMMARY

Hypothetical erosion assessment models have been developed for determining some of the onsite and downstream damage possible by logging. By using the soil erosion potential for several yarding systems to determine the erosion assessments, total relative logging costs for each system may be evaluated. This evaluation method may show that environmentally acceptable advanced systems of of yarding could cost less than traditional yarding systems at some locations. An example of the possible cost advantage of using an advanced system is given for a fire salvage study area described in Klock (1975).

When these suggested hypothetical models are used as tools for making environmentally acceptable land management decisions, the cost advantage of using advanced tree removal techniques may be more evident in many areas of our western forests.

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A Simulation-based Approach for Evaluating Logging Residue Handling Systems

B. Bruce Bare
Benjamin A. Jayne
Brian F. Anholt

PACIFIC NORTHWEST
FOREST AND RANGE EXPERIMENT STATION
US DEPARTMENT OF AGRICULTURE, FOREST SERVICE
PORTLAND, OREGON

Abstract

Describes a computer simulation model for evaluating logging residue handling systems. The flow of resources is traced through a prespecified combination of operations including: yarding, chipping, sorting, loading, transporting, and unloading. The model was used to evaluate the feasibility of converting logging residues to chips that could be used, for example, to generate electrical power. Empirical results obtained for two processing schemes are reported.

KEYWORDS: Computer programs, forest residues, logging operations work sequence.

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Introduction

Many segments of society are concerned over the large quantities of wood residues generated by logging operations in the Pacific Coast States and across the Nation. Forest management and logging operations are conservatively estimated to produce 9.6 billion cubic feet of residues annually (USDA Forest Service 1972).[1] In Washington, Oregon, and California, logging residues over 4 inches in diameter and over 4 feet long resulting from timber harvesting are estimated to exceed 1.1 billion cubic feet annually (Howard 1973).

Forest residues encompass a wide range of materials remaining after logging operations or road construction. Tops, limbs, splintered and rotten logs, bark, and stump-root systems predominate. The quantity of residue in any one of these forms is changing rapidly and likely will continue to do so. Two major factors are responsible: (1) rapidly changing utilization standards and (2) harvesting of younger stands. Due to the size of capital investments, steps taken today to increase the level of residue utilization must be designed in such a way as to be compatible with the character of residues available in the future. Biomass information on forest stands, coupled with predictions of changing utilization standards, gives some indication of the quantities and types of residues that will be produced in the future.

Irrespective of the type of material marketed, the central problem is one of devising processing schemes which minimize production costs. The term "processing," as used herein, includes all steps that must be taken to convert residues to a basic forest product; i.e., all forms of manufacturing, handling, transporting, and storing. With few exceptions, the basic products which can be produced from residues have low market value. Consequently, a careful examination of all possible processing schemes for minimizing the cost of production must be undertaken. Minimization of production costs, in turn, depends on full use of labor and machines. Because of the critical nature of this aspect of the problem, the approach reported herein should have wide applicability for other wood conversion problems. It must be remembered, however, that production costs are only a portion of the total cost structure. Although not dealt with here, environmental costs should be considered.

The work reported in this paper was conducted in cooperation with the Forest Residues Program (FRP) of the Pacific Northwest Forest and Range Experiment Station. The research objective of the FRP is to develop, test, and evaluate ways to reduce accumulations of forest residues to maintain the productivity and quality of the forest environment. Our study relates to the FRP goal of promoting increased utilization of wood fiber and the energy contained in forest residues. The focus for the study was the Estacada and Clackamas Ranger Districts of the Mount Hood National Forest in Oregon. Many of the data used in the study were obtained from these two districts.

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[1] U.S. units are used in this report; see appendix for conversion factors.

The study, designated "Residues for Power" (REPO), was initiated to obtain results which could be used as an aid in determining the feasibility of utilizing forest residues to generate electrical power (Grantham et al. 1974). Our primary objective was to develop a computer simulation model for describing the flow of residues from the forest to a hypothetical power generation facility. The model traces the flow of forest residues through a prespecified combination of operations including: yarding or skidding, loading, transporting, unloading, sorting, and chipping. All operations can be linked together in numerous combinations. Rate functions associated with each of the operations govern the flow of residues. The model terminates with the delivery of chips to the hypothetical power generation site.

Since the simulation model was designed for the overall function of materials handling, it can be used to analyze a wide variety of wood utilization problems. As an example, the model could be modified for use as a timber harvesting and transportation simulator. This particular application has been studied by the Canadian Department of the Environment using a similar but different materials handling system (Newnham 1972a, 1972b). Other publications on harvesting simulation models are noted in the Literature Cited section of this paper (Biller and Johnson 1973, Corcoran 1973, Johnson and Biller 1974, Johnson et al. 1972, Martin 1975, Sammis and Corcoran 1974, Sarna and Corcoran 1973, Schmidt 1970, Seppälä 1971, Sinner 1973, Webster 1975).

To permit analysis of the many possible equipment configurations, maximum flexibility was an important design criterion. When one recognizes the many forms in which residues exist, the extensive area over which they are distributed, and the number of methods available for handling, converting, and transporting them, one sees that many configurations are possible. Only two materials handling configurations are illustrated in this paper. However, the potential for using the model for other applications should be readily apparent.

General Description of the Model

The model consists of three components: (1) operations, (2) stores, and (3) decisions, which are arranged serially to permit the processing of residues from a logging site to a point of utilization. Stores, which appear between operations, reflect the level of wood residues in inventory. The level of a store indicates the backlog of residues developing between two operations. Different equipment configurations directly influence the rate functions for an operation and, hence, the level of wood residue in a store at any time.

In contrast to stores, each operation is characterized by a rate function which determines the rate at which residues are moved from one store to another. In the models devised for residue processing, yarding, chipping, sorting, loading, transporting, and unloading are designated as operations. Each of these operations will frequently be made up of a set of characteristic activities. The activities, in turn, are modeled by a combination of several probability distribution functions. Consequently, the model can best be described as a compartment model made up of stochastic rate functions.

REPO is designed to simulate any of the sequences of operations depicted in figure 1. In this figure, the three components are represented symbolically as:

(1) operations - ○

(2) stores or compartments - ▭

(3) decisions - △

Closer inspection of figure 1 indicates that REPO encompasses six basic operations: yarding, chipping, sorting, loading, transporting, and unloading. Only one of these, chipping, involves the conversion of wood from one form to another.

Either of two types of yarding, cable or tractor skidding, can be included in the model. In our model, both cable and tractor logging are made up of the usual set of characteristic activities: outhaul, choking, inhaul, and unhooking. Consequently, several types of cable logging (i.e., high-lead and skyline) and tractor logging with either crawler or four-wheel skidders can be represented.

Chipping converts raw residue to chipped form. Because of the rapidity and integrated character of this operation, designation of any of its component activities was considered unnecessary.

Sorting of residues can be accomplished at any one of several locations, including the landing, sorting yard, or the point of utilization. Sorting can be accomplished with several machines including the common log loader, as well as a vehicle equipped with a front-end lift. Depending on the number of sortings undertaken at a particular location, sorting can be made up of a few to many separate activities.

Sometimes the three remaining operations--loading, transporting, and unloading--are lumped together; because of real and anticipated equipment interactions in other operations, they are recognized separately in REPO.

Loading is normally accomplished with a hydraulic log loader equipped with a grapple or an older cable-operated loader equipped with tongs. Because the loading operation is cyclic and rapid, knowledge of its component activities is usually unnecessary.

In the transporting operation, the model will accommodate the movement of residue in raw material form as well as in chipped form. Transporting is accomplished with any one of three types of trucks: (1) log trucks, (2) open gondola trucks, and (3) chip vans. Normally, transporting requires the introduction of several component activities. At a minimum, the different rates of truck movement over the various types of roads encountered in a given geographic area are needed.

Unloading is normally accomplished with a single item of equipment. Irrespective of the type of equipment, the total operation is usually of such a continuous nature that knowledge of component activities is unnecessary. Several types of unloading systems, each with its peculiar

Figure 1.--Flow chart of REPO, flow diagram branches A, B, and C.

○ - *operations;* ▭ - *stores or compartments;* △ - *decisions.*

Stations

0 = cutting unit
1 = landing
2 = residue processing site on forest
3 = power generation site on forest
4 = residue processing and power generation site off forest

Symbol definitions

R = residue
SR = sorted residue
CH = chip
S = sort
T = transport
LT = load for transport

LCH = load chipper
U... = unload... (where... is some product)
RTS = yard with rubber-tired skidder
CT = yard with crawler tractor
HL = yard with high-lead
Y = yard

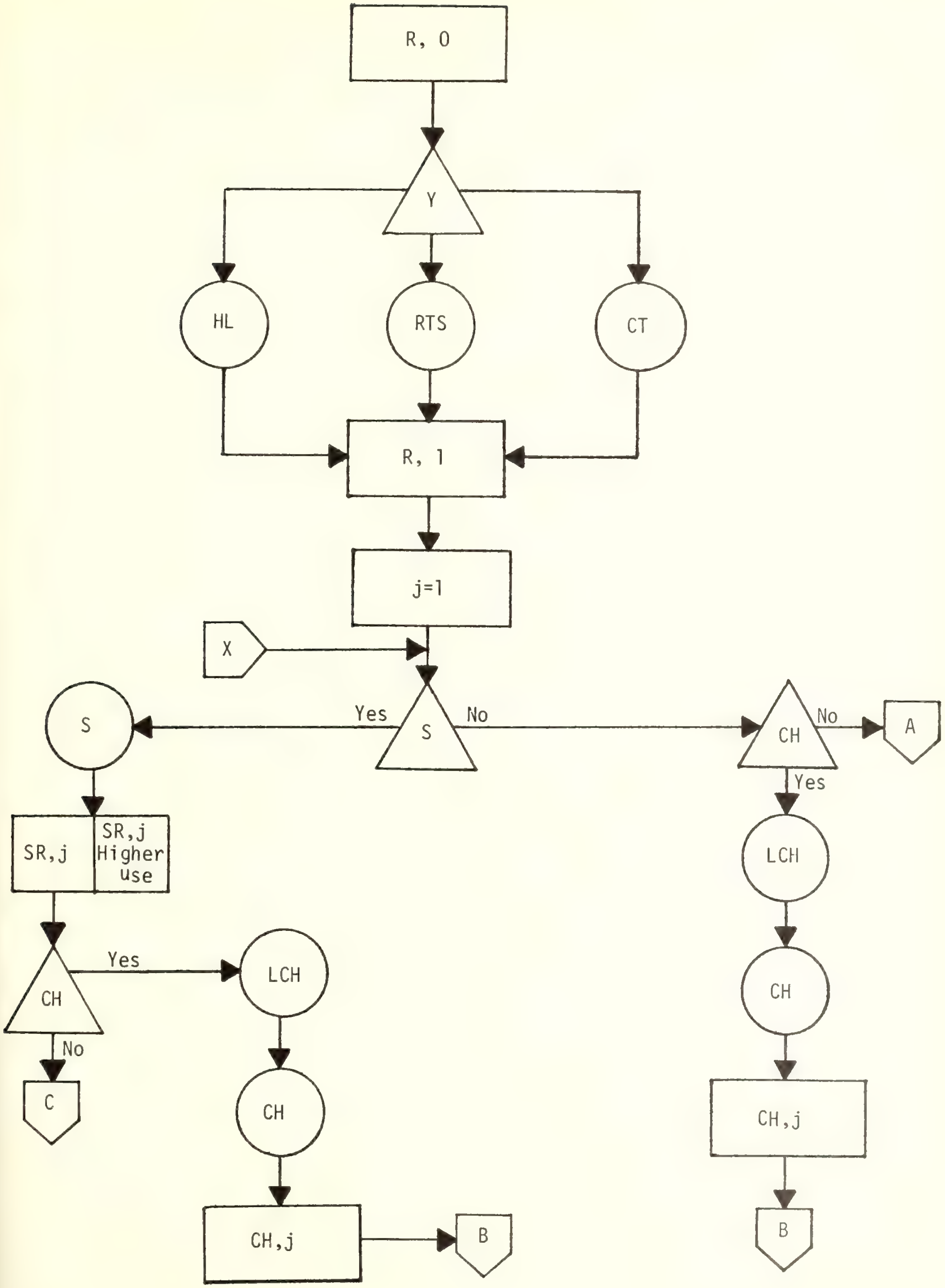

R, 0
Y
HL
RTS
CT
R, 1
j=1
X
Yes
S
No
S
CH
No
A
Yes
SR,j
SR,j Higher use
CH
Yes
LCH
No
C
CH
CH,j
B
LCH
CH
CH,j
B

Figure 1.--Continued.

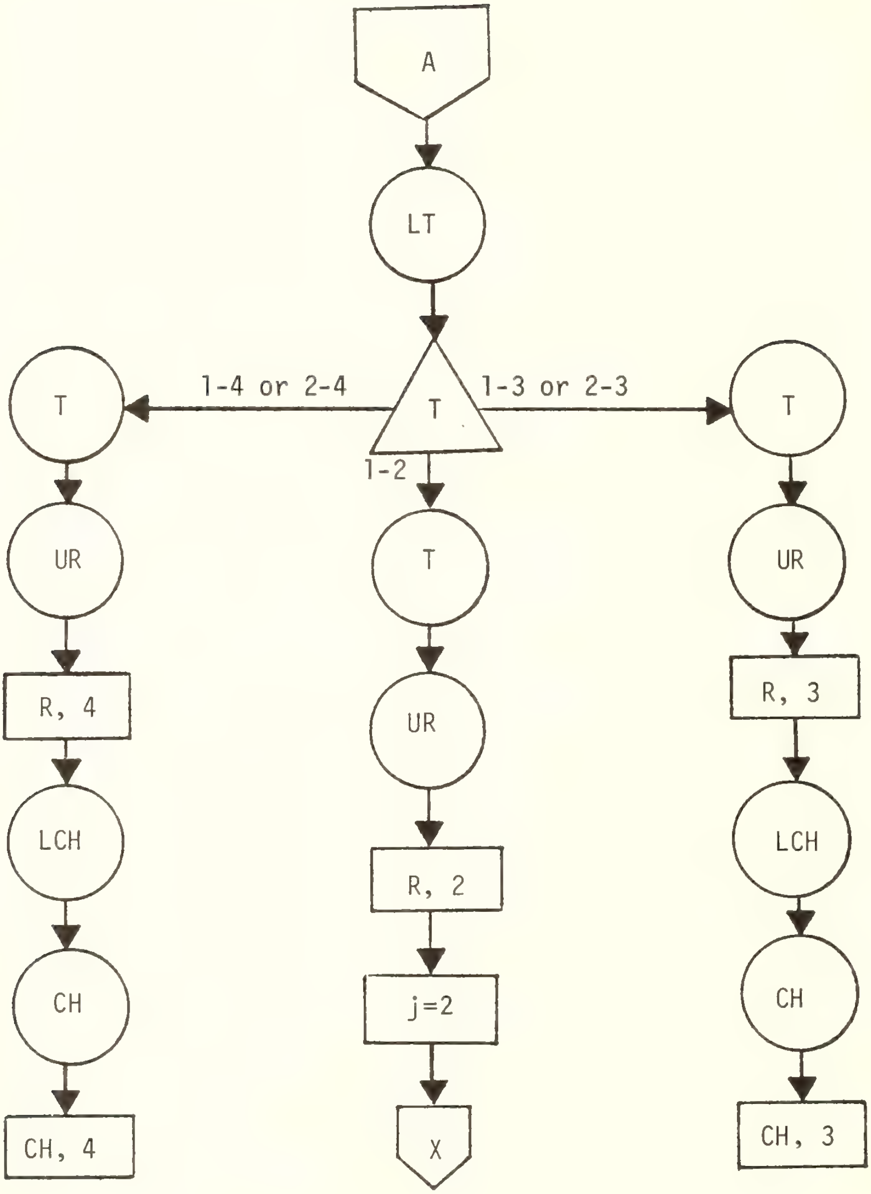


Figure 1.--Continued.

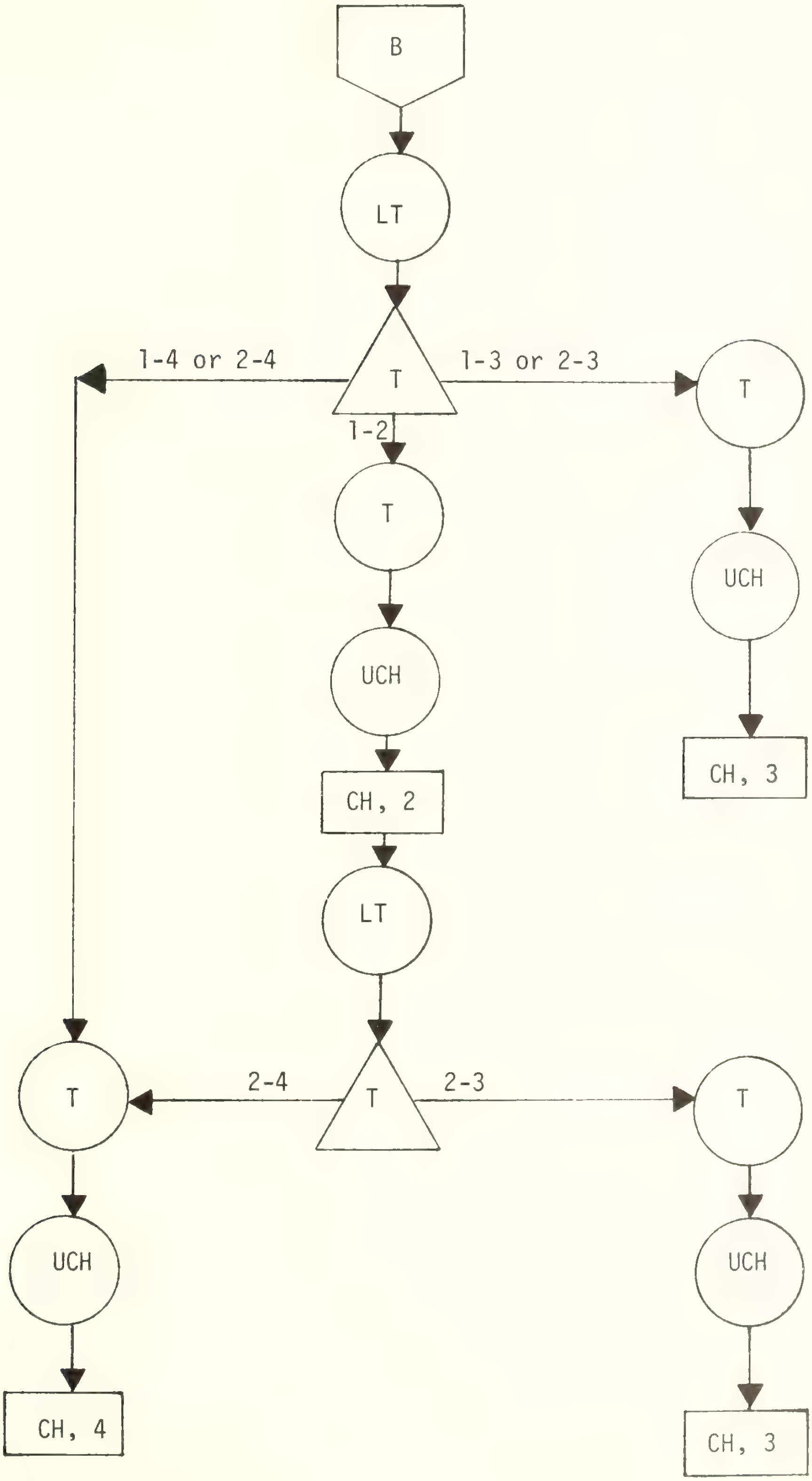
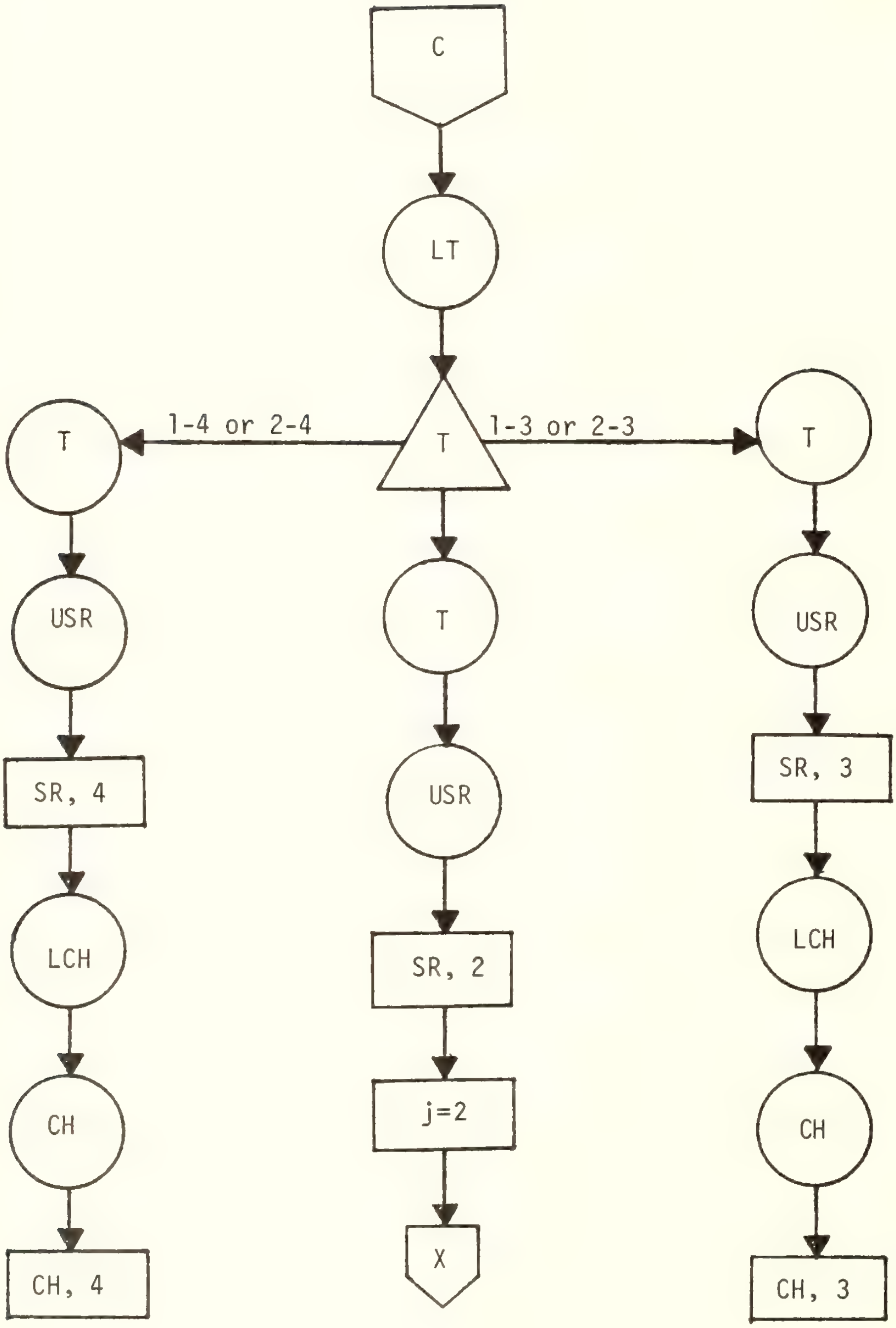


Figure 1.--Continued.



characteristics, may be required to accommodate the various types of trucks incorporated in a complex model.

Simulation models, such as REPO, which consist of a series of operations through which material is processed, require two basic types of accounting for their operation. One accounting system encompasses the total elapsed time of a normal workday--say 8 or 9 hours. A second accounting system is required to monitor the quantity of material processed through each operation. Combination of the two establishes the rate of production of each operation. Both accounting systems are fundamental to the functioning of such simulation models.

Many subdivisions of a workday are normally required to account for elapsed time. We prefer to adopt two all-inclusive categories: (1) productive and (2) unproductive or lost time. Productive time is time during which material is actively processed. It is made up entirely of the cycle times of the operations included in the model. Unproductive or lost time is time during which material is not actively being processed. Subdivisions of unproductive time, outlined below, are highly desirable in most simulation models.

Each operation is characterized by a basic cycle time required for its completion. The cycle is repeated many times during a normal workday and is interrupted only by actions resulting in lost time. As indicated earlier, subdividing the cycle time into two or more parts which we have defined as activities is sometimes advantageous. This type of subdivision is particularly appropriate if the activity can be clearly identified and is of sufficient duration to justify a separate designation. Subdivision of the yarding cycle into outhaul, choking, inhaul, and unhooking is commonly used and can be highly desirable in some models. However, a breakdown of some operations into component activities may introduce additional and unneeded complexity.

Irrespective of the particular operation, repeated measurements of a basic cycle are necessary to obtain a measure of its mean value and of the dispersion about the mean value. A theoretical distribution for the cycle time of a high-lead yarder is shown in figure 2. Note that, in

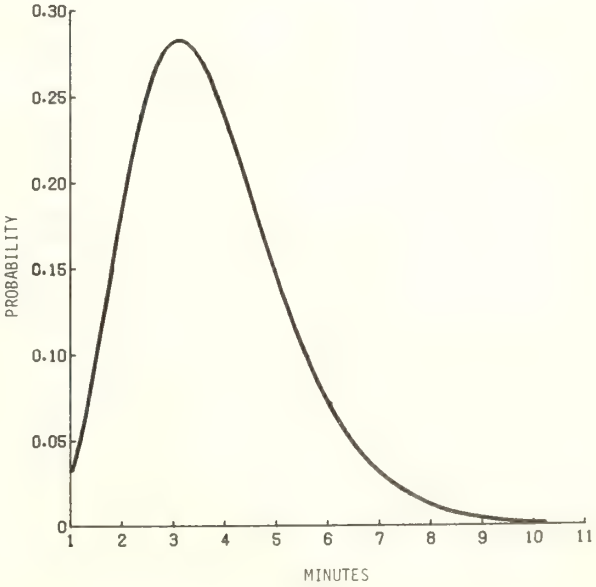


Figure 2.--Theoretical probability distribution of cycle time for a typical high-lead relogging operation for distances ranging from 101 to 200 feet.

this particular example, the yarding cycle time is described by a gamma probability distribution. The mean yarding cycle time is 3.73 minutes, and the standard deviation is 1.52 minutes. This particular type of distribution, typical of many high-lead operations, encompasses yarding distances ranging from 101 to 200 feet.

The productive cycles of each operation are interrupted by unproductive or lost time; and our experience suggests five broad categories: (1) machine warmup time, (2) crew rest time, (3) operational delays, (4) equipment relocation, and (5) lost time due to equipment breakdown (downtime). Our grouping of unproductive time is reasonably consistent with that of others reported in the literature. Clearly, each category can be further divided just as cycle time can be subdivided into various activities.

Operational delays are particularly important examples of unproductive time for which subdivisions may be important. For example, several kinds of delays occur during yarding; certain ones may be associated with outhaul, choking, inhaul, or unhooking activities. Finally, just as cycle time is represented by a distribution of times, any one of the categories and subcategories of unproductive time is also characterized by a mean value and a distribution. The shapes of these distributions are strongly influenced by the frequency with which a particular category of unproductive time occurs in a given operation.

In addition to an accounting system for the elapsed time of a workday, an accounting must be kept of the quantity of material processed. For most operations, a quantity will be associated with each of the repeated basic operating cycles. For example, during yarding, a certain number of logs of a range of sizes is transferred to the landing on completion of the cycle. Because both size and number of logs to be choked vary from cycle to cycle, the quantity of material processed during a cycle is variable and is represented by a distribution.

In summary, simulations of the type represented by REPO require an accounting of both productive (cycle) and unproductive (lost) time and the quantity of material processed during the productive time. Both accounting systems require the use of a number of distribution functions to realistically account for inherent variability. Precision is incorporated into models of this type by allowance for as many sources of variation as possible

Operational Characteristics of REPO

REPO was designed to permit an analyst to alter the sequence, type, and number of operations to be evaluated in any one simulation run. In its present form, REPO permits the evaluation of any combination of operations displayed in figure 1. The sequence and type of operations to be evaluated must be specified as well as the relationships between operations. Lastly, the activities into which each operation is to be divided must be identified. Obviously, the exact number of activities identified for a particular operation will vary greatly between users. This flexible model structure was implemented on the computer with the SIMCOMP preprocessor, a brief discussion of which follows this section.

REPO operates as a fixed time increment simulator, with each 9-hour workday corresponding to one time increment. During each day of simulated activity, REPO serially calculates the rate at which residues will be processed from one compartment (store) to another. Both the fixed time increment and serial character of REPO have important ramifications. For example, the fixed time character does not permit REPO to track the occurrence of a machine breakdown within a given time period. Because of this characteristic, REPO does not account for interactions between dependent operations within a time period. However, the model does account for interactions between time periods. Further, because of the serial character of REPO, during any time period, the last operation in a given processing sequence is not simulated until all preceding operations have been simulated. Thus, if the last operation in a processing sequence suffers a machine breakdown, it will have no effect on previous operations during the same time increment. Maximum limits can be set for each store to partially circumvent the impact of this characteristic. These limits would have to be carefully determined so as not to overconstrain any operation.

A snapshot of the system at any time reveals the amount of residue in various stores in the system. At the conclusion of a computer run of 130 simulated workdays (i.e., 6 months), tabular and graphical output reveals the total amount of residue processed, the amount of residue remaining in the system in various stores, and an evaluation of equipment efficiency.

To understand how REPO determines the amount of forest residue to be processed during each simulated day, consider this example involving the loading operation: First, each workday (one time unit) of 540 minutes is reduced by subtracting the unproductive time expected that day. In general, this is accomplished by sampling from distributions representing the various categories of unproductive time such as machine warmup, crew rest, operational delays, and equipment breakdowns. In the current version of REPO, construction of separate distributions for each of the above categories is not possible because of a lack of data. Instead, each workday is reduced by a constant 15 percent to account for machine warmup, crew rest, and operational delays. The amount of unproductive time due to equipment downtime is then subtracted; this unproductive time is estimated from a distribution representing the number of machine breakdowns expected that day. If none are expected, the machine begins to load residue. If, however, a breakdown is indicated, a sample is drawn from the distribution function representing the length of downtime for loaders. This downtime further reduces the productivity of the loader on that day.

After unproductive time is determined, the simulator samples from the distribution function representing the cycle time for loaders. Next, another distribution function is sampled to determine the number of pieces to be loaded during the cycle. A check is made during each cycle to determine if the productive time available for loading has elapsed or if another cycle can be completed. Similarly, a check is made during each cycle to determine if any residue is available for loading or if the loader should be moved to the next landing. If no residue exists, the machine either is idle or is moved to another landing. In the latter case, additional unproductive time occurs during the machine relocation process.

REPO simulates the relogging of forest residues in a given region by sequencing through a list of available cutting units. Each cutting unit is further divided into a number of settings. An assumed road network consisting of spur, main line, and State highways interconnects the various cutting units.

A series of attributes describing each cutting unit is generated from distribution functions empirically constructed to represent data from a particular area or region. These attributes are:

1. Average slope yarding or skidding distance per setting
2. Area of a setting
3. Number of settings per cutting unit
4. Average slope per setting
5. Area of a cutting unit.

Three additional distribution functions are used to assign road characteristics for each cutting unit. Distribution functions are used to generate the mileage for:

1. Spur roads
2. Main line haul roads
3. State highways.

These mileages permit the model to account for travel time to and from each cutting unit at varying rates of speed. However, they do not permit the spatial location of cutting units on a Cartesian coordinate system.

The residue on each cutting unit is characterized by the gross and net cubic-foot volumes and the number of pieces of residue per acre by diameter and length classes. The total volume to be relogged is determined from the minimum and maximum diameter and length classes of pieces to be relogged, the average volume per piece, and the total number of pieces per acre.

All volume production figures in REPO are given in cubic feet of solid wood. These relationships can be used for other units of measure: 1 unit of chips ≅ 200 cubic feet of wood chips ≅ 80 cubic feet of solid wood ≅ 1 cord ≅ 2 green tons or 1 air-dry ton.

Although REPO was designed to be as flexible as possible, certain limiting assumptions were necessary. For example, REPO permits, at most, two transport operations between the logging site and the point of final utilization. Second, only one yarder is permitted per setting and only one setting can be actively relogged at a time. Third, except for the first day of simulated activity, all trucks are assumed to originate and terminate their daily activities at a source of residue awaiting transport. Essentially, this implies that trucks are not dispatched unless a round trip can be completed between the origin and the destination before the end of a workday. Fourth, cutting units are assumed to be clustered in groups of six so that the movement of equipment over State highways is only required every sixth unit. Lastly, REPO was designed to permit the evaluation of on-forest as well as off-forest locations of residue processing and power generation sites. As shown in figure 1, two on-forest sites (stations 2 and 3) or one off-forest location (station 4) is permitted. Further, any one of six possible locations is allowed for stations 2 or 3, but only one location for the off-forest site is permitted.

Programing Language

The SIMCOMP programing language was used to translate the symbolic representation of REPO into the computerized version. SIMCOMP is a machine-dependent simulation language written at Colorado State University for the CDC 6400 computer (Gustafson and Innis 1972). The language is designed for compartment-oriented simulation models. Programing in SIMCOMP requires an understanding of the FORTRAN IV language, since the SIMCOMP compiler creates a FORTRAN program which is compiled by the CDC Extended FORTRAN compiler.

SIMCOMP programs are divided into two sections--source program and data. The source program contains SIMCOMP directives and FORTRAN statements and subprograms. The data section contains initial values for all parameters and compartments. Varying the sequence of the various subprograms, each representing an operation, makes possible design of unique residue handling systems. The subprograms are invariant with respect to these different configurations.

SIMCOMP was selected as the programing language because of the automatic and flexible handling of the timing mechanism, the ease of obtaining graphical and tabular output, and the capability of examining other materials handling systems. However, computing costs with SIMCOMP are quite high. Furthermore, the language is machine dependent and has received limited distribution to date.

Illustrative Case Study

The following example illustrates the potential utility of REPO for evaluating two sequences of operations for disposing of forest residues. The physical setting for this problem is the Estacada and Clackamas Ranger Districts of the Mount Hood National Forest. These two Districts, located southeast of the city of Portland, have a common boundary--the Clackamas River. The various operations included in the alternatives presented below are designed to occur on either of the Districts or at some point along the State highway which roughly parallels the Clackamas River. Further, all residue is assumed to be transported over this State highway to the town of Estacada. From there, it is transported to Portland--a distance of 30 miles.

REPO does not spatially locate cutting units on a Cartesian coordinate system. Instead, probability distributions characterizing the mileages over which residue is transported from each cutting unit to Portland are utilized. These distributions, indicated in table 1, were derived from data provided by Ranger District personnel. Mileage was obtained from these distributions which, when multiplied by the appropriate travel rates, provided the total round trip travel time from each cutting unit to Portland.

With data supplied by Ranger District personnel, distributions were

Table 1--*Probability distributions in residues for power (REPO)*

Item	Equipment	Type distribution	Parameters[1/]		Mean
Average slope yarding distance (ft)	Cable	Gamma	K=10	A=0.02	500.00
Average slope yarding distance (ft)	Tractor	Gamma	K=13	A=0.04	325.00
Number of settings per cutting unit	Cable	Gamma	K=6	A=2.5	2.40
	Tractor	Uniform	a=0	b=5	2.50
Area of settings (acres)	Cable	Gamma	K=4	A=0.29	13.79
	Tractor	Gamma	K=2	A=0.29	6.90
Average slope per setting (percent)	--	Gamma	K=3	A=0.11	27.27
Spur road distance (mi)	--	Exponential	--	$\lambda=6.67$	.15
Main line haul road distance (mi)	--	Normal	$\bar{X}=12.54$	s=4.137	12.54
State highway distance (mi)	--	Normal	$\bar{X}=29.9$	s=10.1	29.90
Cable yarding, time per turn (min):					
0-100 feet	Cable	Gamma	K=4	A=1.46	2.74
101-200 "		Gamma	K=6	A=1.61	3.73
201-300 "		Gamma	K=8	A=2.10	3.81
301-400 "		Gamma	K=6	A=1.53	3.92
401-500 "		Gamma	K=13	A=2.11	6.16
501-600 "		Gamma	K=5	A=0.78	6.41
601-700 "		Gamma	K=4	A=0.59	6.78
Number of logs per turn	Cable	Normal	$\bar{X}=3$	s=0.67	3.00
Number of breakdowns per day	Cable	Gamma	K=4	A=1.75	2.29
Length of each breakdown (min)	Cable	Exponential	--	$\lambda=0.03333$	30.00
Tractor yarding:					
Number of breakdowns per day	Tractor	Gamma	K=1	A=1	1.0
Length of each breakdown (min)	Tractor	Exponential	--	$\lambda=0.01818$	55.00
Number of logs per turn	Tractor	Gamma	K=5	A=1.16	4.31
Loading:					
Cycle time (min)	Grapple loader	Gamma	K=3	A=0.05	60.00
Number of logs loaded per cycle	Grapple loader	Gamma	K=7	A=5.93	1.18
Number of breakdowns per day	Grapple loader	Gamma	K=4	A=3.74	1.07
Length of each breakdown (min)	Grapple loader	Exponential	--	$\lambda=0.01538$	65.00
Transport:					
Number of breakdowns per day	Log truck or chip van	Exponential	--	$\lambda=2.0$	.50
Length of each breakdown (min)	Log truck or chip van	Exponential	--	$\lambda=0.02222$	45.00
Unloading and sorting:					
Unloading cycle time (min)	Front-end loader	Normal	$\bar{X}=120$	s=30	120.00
Sorting cycle time (min)	Front-end loader	Gamma	K=19	A=3.65	5.21
Number of logs per cycle	Front-end loader	Normal	$\bar{X}=7$	s=2.5	7.00
Number of breakdowns per day	Front-end loader	Gamma	K=1	A=1.0	1.00
Length of each breakdown (min)	Front-end loader	Exponential	--	$\lambda=0.01818$	55.00
Chipping:					
Number of breakdowns per day	Chipper	Gamma	K=3	A=0.05	60.00
Length of each breakdown (min)	Chipper	Exponential	--	$\lambda=0.50$	2.00

[1/] See appendix for a description of these parameters.

generated for average slope yarding (skidding) distance per setting, number of settings per cutting unit, acreage of each setting, and average slope of the cutting unit (table 1).

The per-acre volume of residues on each cutting unit was generated from data supplied by Ranger District personnel. These data were estimated by the line intersect method of measuring forest residues on 12 cutting units of the Clackamas and Estacada Ranger Districts. The units were measured during the summer of 1972. Gross and net volumes by diameter and length classes, gross and net volumes by species composition, and number of pieces per acre by diameter and length classes were determined from the line intersect measurement data.

Distribution functions for each operation incorporated in the two processing schemes had to be developed in addition to distribution functions characterizing the cutting units and the road network. As discussed earlier, distributions were used to represent machine cycle times and rates of productivity as well as the unproductive time due to machine breakdowns. The following discussion reviews the development of all distributions in both models.

SAMPLE MODEL CONFIGURATIONS

Two versions of REPO, Models I and II, were designed to evaluate the two processing schemes. Model I consists of the following operations:

1. Yarding or skidding
2. Loading (chipper)
3. Chipping (at landing)
4. Transporting chips from the landing to Portland
5. Unloading.

The more complex Model II consists of these operations:

1. Yarding or skidding
2. Loading (raw residue)
3. Transporting raw residue from the landing to an on-forest residue processing facility
4. Unloading
5. Sorting
6. Transporting (within sorting yard)
7. Loading (chipper)
8. Chipping (at residue processing facility)
9. Transporting chips from the residue processing facility to Portland
10. Unloading.

Figure 1 indicates that these models are just two of many that can be developed within the framework of REPO. There is no assurance that either of these models will lead to the least-cost production of chips. To date, no attempt has been made to use REPO to identify the least-cost processing scheme.

Six locations for the on-forest residue processing and power generation sites were permitted in the general formulation. In the empirical results reported later for Model II, the on-forest residue processing facility was assumed to be located at Three Lynx, Oregon, one of the six possible locations. The permanent off-forest residue processing and power generation facility was assumed to be in Portland.

Yarding.--The cable yarding operation, relogging with a high-lead, consisted of four activities--outhaul, choking, inhaul, and unhooking. Cycle times for each activity were treated solely as a function of average slope yarding distance. From Adams' (1965) data, seven distributions of yarding time were derived by 100-foot increments of average slope yarding distance. These distributions were characterized by gamma functions, the constants for which are listed in table 1. Mean yarding times of the seven distributions ranged from 2.74 to 6.78 minutes. The distribution function used to represent the number of logs yarded per cycle is also listed in table 1.

Lost time due to equipment breakdown was represented by a combination of a gamma function for the number of breakdowns per day and an exponential function for the length of each breakdown (table 1). Unproductive time due to crew rest, machine warmup, and operational delays was incorporated by reducing each workday of 540 minutes by 10 percent. Only one cable yarding system was allowed per setting.

A fixed time of 17 minutes was allowed for changing cable roads on a setting, and 72 minutes was allowed for changing the setting on a given cutting unit. In general, cutting units on the two Ranger Districts were clustered in groups of six. Consequently, after six cutting units were yarded, the model required moving of the yarder. To simulate typical relocation of equipment, a moving distance equal to twice the length of the main line haul road plus 15 miles of State highway was used in the model. The rate of travel was set at 6 minutes per mile.

The tractor yarding operation also was composed of four activities--outrun, choker setting, skidding, and unhooking. However, because of the characteristics of the available raw data, a distribution of cycle times for tractor yarding could not be constructed. Rather, for tractor logging, the regression equations reported by Adams (1967) had to be adjusted. The equations summarized the best available data at the time the study was undertaken. These equations and the standard errors of estimate incorporated into REPO are listed in the tabulation below. Any number of tractors of either the crawler or four-wheel skidder variety was permitted on a setting.

Unproductive time due to crew rest, operational delays, and warmup for tractors was assumed to be 10 percent of the workday. Downtime characteristics for the tractor were represented by two distribution functions--one for the number of breakdowns per day and a second for length of downtime. The characteristic parameters of these distributions are listed in table 1. The distribution function representing the number of logs per turn also is contained in table 1. The time to move equipment from one setting to another was fixed at 30 minutes. All equipment was moved to a new cutting unit upon completion of yarding of six cutting units. The distance of move was computed with the same assumptions as for the cable yarding system. Travel time was set at 4 minutes per mile.

The regression equations used for simulation of tractor yarding are:

Activity	Regression equation
1. Outrun time (min)	
a. Crawler	$1.341+0.004136(\mathrm{AVYD})$
b. Four-wheel skidder	$0.8534+0.002951(\mathrm{AVYD})$
2. Choker-set time (min)	
a. Crawler	$-1.084+2.65(\mathrm{NOLOGS})-0.004776(\mathrm{NOLOGS})(\mathrm{NOPS/AC})+0.00004951(\mathrm{NOPS/AC})^2$
b. Four-wheel skidder	$1.23+0.6952(\mathrm{NOLOGS})+0.002431(\mathrm{NOLOGS})(\mathrm{NOPS/AC})$
3. Skid time (min)	
a. Crawler	$1.22+0.005771(\mathrm{AVYD})$
b. Four-wheel skidder	$-0.08486+0.003425(\mathrm{AVYD})-0.000001057(\mathrm{AVYD})^2+0.009834(\mathrm{AVOL/LOG})(\mathrm{NOLOGS})$
4. Unhooking (min)	
a. Crawler	$0.5228+0.009761(\mathrm{NOLOGS})(\mathrm{AVOL/LOG})$
b. Four-wheel skidder	$1.054+0.2627(\mathrm{NOLOGS})$

where:

AVYD = Average slope yarding distance in feet
NOLOGS = Number of logs per cycle
NOPS/AC = Number of pieces of residue per acre to be skidded
AVOL/LOG = Average cubic-foot volume per piece

Activity	Standard error of estimate (min)	
	Crawler	Four-wheel skidder
Outrun time	1.39203	1.2863
Choker-set time	4.1397	2.6771
Skid time	1.96476	1.1729
Unhook and deck time	1.6652	.8794

Log hauling.--Log hauling consists of three basic operations--loading, transport, and unloading. Loading in the model is accomplished with a hydraulic grapple loader. Two distribution functions were required to characterize the rate of loading--one for cycle time and a second for the number of pieces loaded per cycle. As with the yarding operation, two distribution functions were required to represent equipment downtimes. Each workday was reduced by a constant 15 percent for equipment warmup, crew rest, and operational delays. All the distributions used for loading are listed in table 1. At least two grapple loaders are required at station 1, 2, or 3 if both sorting and chipping or sorting and loading for transport are performed.

A time of 30 minutes was allowed for moving the loader between landings. The distance between clusters of cutting units was computed in the same manner as for cable yarding equipment. Travel time was computed at 4 minutes per mile.

Unloading of log trucks was accomplished with a four-wheeled front-end loader having a capacity of about 50 tons. The characteristic constants of the distributions used to represent the cycle time, number of logs per cycle, and equipment breakdown are listed in table 1. Each workday was reduced 10 percent for machine warmup, crew rest, and operational delays. The time required to unload a chip van by hydraulic lift was assumed to be a constant 17 minutes. In Model II, the front-end loader located at station 2 unloads trucks and transports residue in the sorting yard. First priority is given to the unloading operation.

Sorting.--In Model II, sorting of the residues takes place at station 2. This operation, of course, requires a sorting yard large enough to handle the volume of material being processed. Sorting is accomplished with a hydraulic grapple loader for segregating the material into two or more grades and a front-end loader for transporting the material across the sorting yard. The characteristics of the grappler loader used for sorting are identical to those described earlier. The front-end loader used for transporting material across the yard is identical to that used for unloading logs. The distribution functions for sorting cycle time and the number of logs unloaded per cycle are shown in table 1.

Chipping.--A portable chipper with a nominal production rate of 1,200 cubic feet of solid wood per hour was used in both models. Downtime characteristics were represented by the two distribution functions listed in table 1. Each workday was reduced by 15 percent for equipment warmup, crew rest, and operational delays. If chipping was completed at the landing, 45 minutes were allowed for moving the chipper between settings. Distances were computed in the same manner as for cable yarding equipment. A rate of 6 minutes per mile was allowed for computing total travel time. No lost time for moving was recorded for a chipper stationed at a sorting station as in Model II.

RESULTS OF THE SIMULATION

The distribution functions contained in table 1 were incorporated into the computer version of REPO where they were used to simulate 6 months of yarding and processing residues. In addition to the information presented above, it was also necessary to indicate:

1. Number of pieces of equipment to be evaluated on any given run of the simulator
2. Cost of operating equipment
3. Labor costs
4. Minimum and maximum diameter and length classes of pieces to be processed
5. Maximum allowable spur and main line haul road distances
6. Maximum slope on which tractors could safely operate
7. Type of skidders (i.e., four-wheel or crawler) and trucks (i.e., log or chip van) to be evaluated.

The equipment configurations evaluated in Models I and II are:

	Model I	Model II		Model I	Model II
Yarder	1	1	Chippers	1	1
Four-wheel skidder	2	2	Chip vans	2	2
Grapple loaders	1	4	Log trucks	0	2
Front-end loaders	0	2			

Table 2 indicates the machine and labor costs associated with each model. All costs were taken from BLM schedule 18 (Bureau of Land Management 1973) except those reported for log trucks, chip vans, and chippers. These latter costs were derived from personal communication with various logging superintendents.

Table 2--*Equipment and labor costs in residues for power (REPO), Models I and II*

Operation	Model Number	Per hour costs		
		Equipment	Labor	Total
		- - - -	*Dollars*	- - - -
Yarding[1]	I and II	17.62	33.59	51.21
Skidding[2]	I and II	11.46	22.62	34.08
Grapple loader	I	4.17	9.32	13.49
Grapple loader	II	16.68	37.28	53.96
Chipper[3]	I and II	15.41	--	15.41
Front-end loader[4]	II	11.46	15.80	27.26
Log truck[5]	II	16.40	13.24	29.64
Chip van[5]	I and II	16.40	13.24	29.64

[1] Yarding equipment consisted of a high-lead mobile yarder operated by a crew of 4.

[2] Skidding was performed by a 4-wheeled rubber-tired skidder (\$5.73/h) operated by a tractor operator (\$7.90/h) plus 1 laborer (\$6.82/h).

[3] Chipping equipment consisted of a portable chipper operated by loader operator.

[4] Front-end loader equipment rate was same as that for rubber-tired skidder (\$5.73/h). Operator rate was \$7.90/h.

[5] Equipment rates for both log trucks and chip vans were assumed equal (\$8.20/h) with labor rates of \$6.62/h.

In both Models I and II, cutting units with slopes of less than or equal to 15 percent were yarded by four-wheel skidder. Also, pieces with diameters of 0 to 36+ inches and lengths of 4 to 20+ feet were assumed to be yarded to the landing. Spur roads over one-half mile and main line haul roads over 20 miles long were not permitted in the model.

For an evaluation of the performance and sensitivity of REPO, both Models I and II were replicated five times. These replications were necessary because of the probabilistic nature of REPO and were performed by reinitializing the pseudorandom number generator before each simulation run. However, no attempt was made to determine whether five replications represented an adequate sample size. The results of one of these replications for Model I are illustrated in figure 3.

Figure 3*A* shows the level of residues remaining on each cutting unit as it is yarded. As illustrated in figure 3*A*, three cutting units were relogged over the 6-month period, with the third unit still being treated at the end of the 6th month of simulated time.

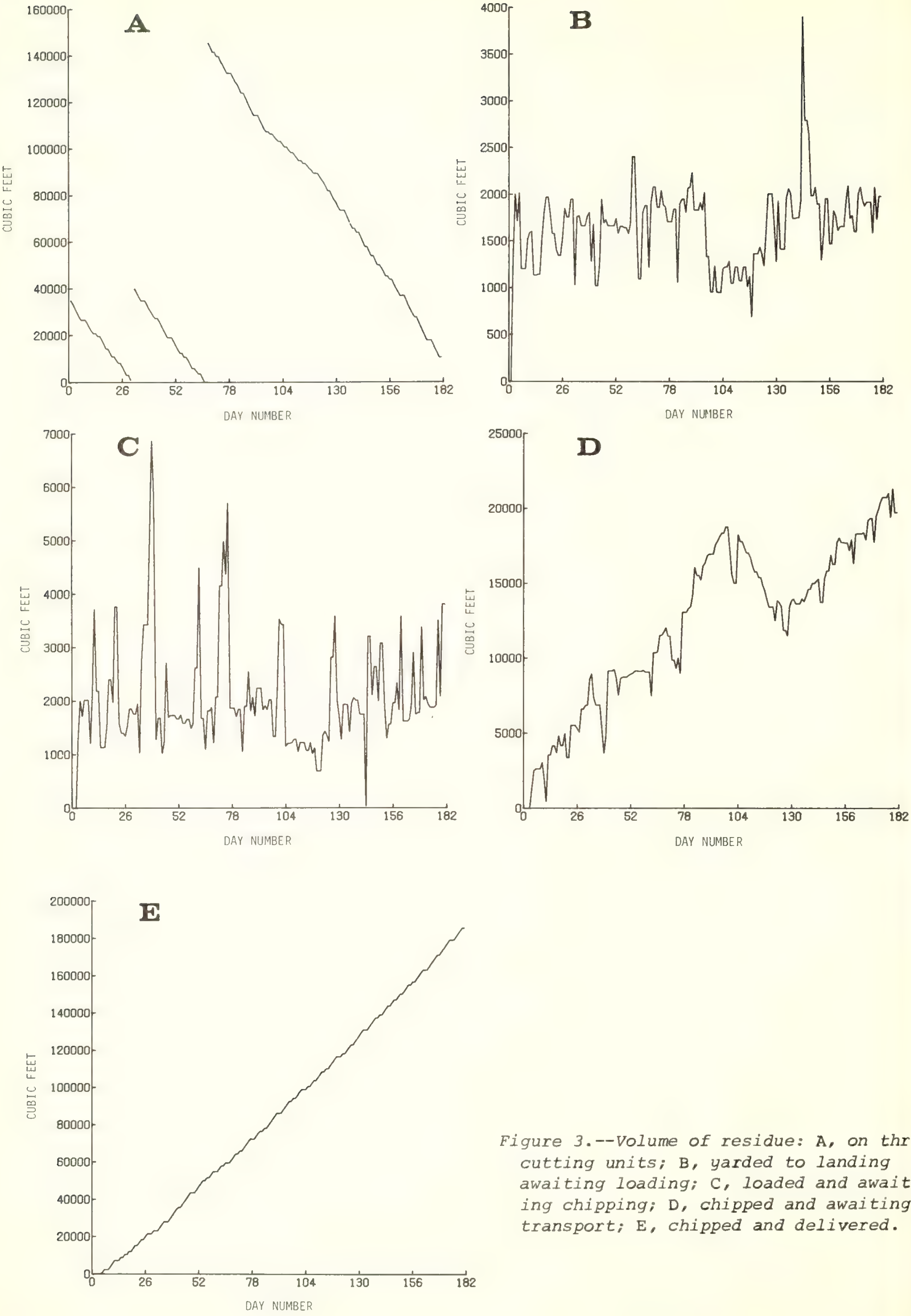


Figure 3.--Volume of residue: A, *on three cutting units;* B, *yarded to landing awaiting loading;* C, *loaded and awaiting chipping;* D, *chipped and awaiting transport;* E, *chipped and delivered.*

Figure *3B* depicts the volume of logging residue yarded or skidded to the landing, that has not been loaded into the chipper. As an example, during the 145th day of simulated time, the level of residue in this compartment increased to a peak of almost 4,000 cubic feet of solid wood. This occurred because the loader had broken down that day, allowing the residue inventory to build up at that point in the processing sequence. If desired, peak volumes like this can be avoided if a maximum limit is set on store capacities. No limits were set on any of the compartments depicted in Model I or Model II. Consequently, peak volumes shown in the graphs in figure 3 may be unrealistic. Low points in figure *3B* correlate with either a machine breakdown or a reduction in rates of production due to some peculiar characteristic of the cutting unit being relogged. For example, the graph shows a substantial decrease in the volume of yarded residue between days 90 and 105. This was due to the large average slope yarding distance generated for the setting being relogged during this period. In fact, this setting had the largest average slope yarding distance of all settings relogged during the 6-month period.

Figure *3C* shows the volume of residue processed by the loader but not chipped. As in figure *3B*, there are large fluctuations in the level of residue at this particular point in the processing sequence which could be minimized if maximum limits were set on store capacities. High points correlate with breakdowns of the chipper and low points with breakdowns of the loader.

Figure *3D* is a graph of the volume of chipped residue at the landing awaiting transport. This volume could be reduced if either a maximum limit were set on store capacity or additional chip vans were added to the system. Figure *3E* depicts the amount of chipped residue delivered to the off-forest residue processing and power generation facility. Similar results were obtained on successive runs of the simulator. These results are discussed below.

Model I

Table 3 contains a summary of the simulation results for the five replications of Model I. Three of the compartments, or points of storage, are defined at the bottom of the table .

The cost of delivering chips to Portland is computed from the statistics summarized in table 4. On the average, 2,103 units of chips with a standard deviation of 336 units are delivered with a mean daily delivery rate of 16.2 units and a standard deviation of 2.6 units. Cost data from table 2 and the mean percent utilization rates for the cable yarder and the two four-wheel skidders as shown in table 5 were used to compute the cost of delivering a unit of chips to Portland. The final costs in table 6 reflect the percent of time the equipment was actually used to yard or skid forest residues. The costs do not

Table 3--*Summary of inventory in residues for power (REPO), Model I (130 workdays)*

Replication number	Compartment number[1]					
	1		2		3	
	$\bar{x}$[2]	s[3]	$\bar{x}$[2]	s[3]	$\bar{x}$[2]	s[3]
	Cubic feet					
1	1,644	507	2,094	1,047	12,465	6,262
2	1,346	439	1,317	689	3,920	2,695
3	1,735	618	1,802	994	28,569	10,720
4	1,274	514	1,437	623	9,058	3,573
5	1,367	862	1,330	752	3,836	6,279

[1] Compartment numbers refer to points of storage within the sequence of operations being simulated. For Model I, the compartments contain: 1 = volume of residue yarded to landing waiting to be loaded, 2 = volume of residue loaded into chipper awaiting chipping, 3 = volume of chipped residue awaiting transport.

[2] Mean.

[3] Standard deviation.

Table 4--*Summary of production in residues for power (REPO), Model I*

Replication number	Total production (130 workdays)		Average daily production rates	
	Wood	Units of chips[1]	Wood	Units of chips[1]
	Cubic feet		*Cubic feet*	
1	187,121	2,339	1,439	18.0
2	168,636	2,108	1,297	16.2
3	192,104	2,401	1,478	18.5
4	169,218	2,115	1,302	16.3
5	123,980	1,550	954	11.9
Mean	168,212	2,103	1,294	16.2
Standard deviation	26,861	336	206	2.6

[1] 1 unit of chips $\cong$ 80 ft^3 of solid wood.

Table 5--*Utilization rates for two 4-wheel skidders and cable yarder in residues for power (REPO), Model I*

Replication number	Percent of time equipment utilized	
	4-wheel skidders	Cable yarder
1	17	83
2	28	72
3	4	96
4	34	66
5	19	81
Mean	20	80
Standard deviation	11	11

Table 6--*Costs of production in residues for power (REPO), Model I*

Equipment	Total hourly cost	Replication number				
		1	2	3	4	5
		Dollars				
Cable yarder	51.21	42.50	36.87	49.16	33.80	41.48
Four-wheel skidder	34.08	5.79	9.54	1.36	11.59	6.48
Grapple loader	13.49	13.49	13.49	13.49	13.49	13.49
Chipper	15.41	15.41	15.41	15.41	15.41	15.41
Chip vans	29.64	29.64	29.64	29.64	29.64	29.64
Total per hour	--	106.83	104.95	109.06	103.93	106.50
Total per day[1/]	--	961.47	944.55	981.54	935.37	958.50
Cost per unit of chips	--	53.42	58.31	53.06	57.38	80.55
Average unit cost	60.54					
Standard deviation	11.42					

[1/] 9 hours.

reflect charges for tasks other than yarding or skidding. This assumption applies to both Models I and II. As shown in table 6, the five replications of Model I produced an average cost of $60.54 per unit of chips, with a standard deviation of $11.42.

Using the empirical results obtained from the five replications, we can set confidence limits around the mean cost of delivering chips if the above sequence of operations is used. Because it was not possible to generate the entire cost distribution, it is impossible to estimate the probability function for the cost of chips delivered at Portland. However, using Chebyshev's inequality, a distribution-free method, we can determine with 75-percent confidence that the "true" unit cost for Model I will lie between $60.54 ± $22.84. With approximately 89-percent confidence, we can say the "true" cost will lie between $60.54 ± $34.26. Thus, we are able to provide an interval estimate for the forecasted cost of relogging selected cutting units using the materials-handling configuration represented in Model I.

Model II

The results of the five replications run for Model II are summarized in table 7.

A summary of total chip production, as delivered at Portland, is shown in table 8. On the average, 2,086 units of chips with a standard deviation of 83 units are delivered with a mean daily production of

Table 7--*Summary of inventory in residues for power (REPO), Model II (130 workdays)*

(In cubic feet)

Replication number	Compartment number[1]									
	1		2		3		4		5	
	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]
1	1,429	560	1,875	746	1,500	766	1,559	664	1,364	684
2	1,576	646	2,159	963	1,360	557	1,567	949	1,380	1,068
3	1,622	894	2,494	1,576	1,320	769	1,569	799	1,680	985
4	1,575	900	1,718	777	1,331	536	1,320	541	1,429	612
5	1,391	435	1,874	705	1,576	680	1,322	536	1,589	835

Replication number	Compartment number[1]									
	6		7		8		9		10	
	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]	$\bar{X}$[2]	s[3]
1	1,241	902	4,749	2,881	1,246	706	1,646	1,141	1,651	1,209
2	1,490	881	4,685	3,194	1,393	1,272	2,058	1,163	2,072	2,339
3	1,158	926	4,613	3,034	1,945	2,175	1,001	1,096	2,119	1,250
4	1,425	740	4,656	3,123	1,462	790	1,289	883	1,460	1,144
5	1,168	796	4,341	2,806	1,140	740	1,459	1,095	1,889	1,007

[1] 1, volume of residue yarded to landing waiting to be loaded; 2, volume of residue loaded onto trucks at landing and awaiting transport; 3, volume of residue delivered to on-forest residue processing station and awaiting unloading; 4, volume of unloaded residue at on-forest residue processing station; 5, volume of residue loaded and awaiting sorting at on-forest residue processing station; 6, volume of residue waiting to be chipped; 7, volume of unchipped residue at on-forest residue processing station; 8, volume of chippable residue transported across on-forest residue processing station sorting yard awaiting chipping; 9, volume of residue loaded into chipper awaiting chipping; 10, volume of chipped residue awaiting transport.

[2] Mean.

[3] Standard deviation.

Table 8--*Summary of production in residues for power (REPO), Model II*

Replication number	Total production (130 workdays)		Average daily production rates	
	Wood	Units of chips[1]	Wood	Units of chips[1]
	Cubic feet		*Cubic feet*	
1	163,086	2,039	1,255	15.7
2	176,401	2,205	1,357	17.0
3	169,183	2,115	1,301	16.3
4	167,001	2,088	1,285	16.1
5	158,835	1,985	1,222	15.3
Mean	166,901	2,086	1,284	16.1
Standard deviation	6,616	83	51	0.6

[1] 1 unit of chips $\cong$ 80 ft^3 of solid wood.

16.1 units and a standard deviation of 0.6 unit. The per-unit cost of delivering chips to Portland for Model II is shown in table 9. These unit costs are based on the cost data presented in table 2, and the mean percent utilization rates for the four-wheel skidder and cable yarder as shown in table 10. The mean per-unit cost of chips of $114.09 is considerably greater than the $60.54 per unit obtained for Model I.

This increased cost is due almost entirely to an increased hourly cost, because more men and equipment were used. One factor omitted from the above analysis is the value of the material sorted for higher use at the on-forest residue processing facility.

Again, using Chebyshev's inequality, we can determine with 75-percent confidence that the "true" unit cost for Model II will lie between

Table 9--*Costs of production in residues for power (REPO), Model II*

Equipment	Total hourly cost	Replication number				
		1	2	3	4	5
	- - - - - - - - - - - - *Dollars* - - - - - - - - -					
Cable yarder	51.21	17.41	51.21	40.46	43.53	51.21
Four-wheel skidders	34.08	22.49	0	7.16	5.11	0
Grapple loaders	53.96	53.96	53.96	53.96	53.96	53.96
Log trucks	29.64	29.64	29.64	29.64	29.64	29.64
Chip vans	29.64	29.64	29.64	29.64	29.64	29.64
Front-end loaders	27.26	27.26	27.26	27.26	27.26	27.26
Chipper	15.41	15.41	15.41	15.41	15.41	15.41
Total per hour	--	195.81	207.12	203.53	204.55	207.12
Total per day[1/]	--	1,762.29	1,864.08	1,831.77	1,840.95	1,864.08
Cost per unit of chips	--	112.25	109.65	112.38	114.34	121.84
Average unit cost	114.09					
Standard deviation	4.64					

[1/] 9 hours.

Table 10--*Utilization rates for two 4-wheel skidders and cable yarder in residues for power (REPO), Model II*

Replication number	Percent of time equipment utilized	
	4-wheel skidder	Cable yarder
1	66	34
2	0	100
3	21	79
4	15	85
5	0	100
Mean	20	80
Standard deviation	27	27

$114.09 ± $9.28. With approximately 89-percent confidence, we can say the "true" cost will lie between $114.09 ± $13.92.

The results of both Models I and II indicate that the processing of logging residues for the production of chips varies considerably, depending on the sequence of operations.

Summary

This paper has reported the development of a simulation model useful for evaluating a wide variety of raw materials handling systems encountered when timber is harvested or relogged in the Western United States. Model flexibility was demonstrated through two hypothetical configurations for relogging forest residues. Results obtained for five replications of each model also were reported.

We emphasize at this point that caution must be observed when the results reported herein are interpreted. First, the raw data used to construct the probability distributions incorporated in REPO were obtained from a variety of sources. Some data were taken from published and unpublished reports. Other data necessary to construct many of the distributions were not available. Therefore, these distributions were based on assumed values and relationships. Although we used the best data available, much additional information must be collected before REPO can be operationally useful.

Another reason for carefully interpreting these results is that they apply only to two particular combinations of processing operations. These sequences were selected solely to illustrate the structure and flexibility of the model and not because they lead to the least-cost production of chips. Other residue handling systems might produce equivalent volumes of chips at much lower cost. Thus, before a decisionmaker can reach a valid conclusion on a specific problem, he must extensively test each materials handling sequence. It must be remembered, however, that the usefulness of computer results as a decisionmaking aid is directly related to data reliability.

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Appendix

As discussed in the text of the paper, several probability density functions were incorporated into simulation model REPO. This appendix will interest those desiring additional information concerning these distributions.

Distribution	Density function		Cumulative function
Uniform	$f(x) = \begin{cases} \frac{1}{b-a} \\ 0 \end{cases}$	$a < x < b$ elsewhere	$F(x) = \frac{x-a}{b-a}$
Exponential	$f(x) = \lambda e^{-\lambda x}$	$\lambda > 0$ $x \geq 0$	$F(x) = 1 - e^{-\lambda x}$
Gamma (Erlang)	$f(x) = \frac{A^K x^{(K-1)} e^{-Ax}}{(K-1)!}$	$A > 0$ $K > 0$ (integer) $x \geq 0$	F(x) does not exist in explicit form
Normal	$f(x) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{1}{2}\left(\frac{x-\mu}{\sigma}\right)^2}$	$-\infty < x < +\infty$	F(x) does not exist in explicit form

Conversion Factors - U.S. to Metric

1 inch = 2.54 centimeters

1 foot = 0.3048 meter

1 mile = 1.609344 kilometers

1 ft^3 = 0.0283168 m^3

1 standard cord (4 by 4 by 8 feet) = 3.6245564 m^3

1 short ton (2,000 lb) = 0.9072 metric ton

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NORTHWEST
PLANT NAMES AND SYMBOLS FOR ECOSYSTEM INVENTORY AND ANALYSIS

FOURTH EDITION

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
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ABSTRACT

This paper is basically an alpha code and name listing of forest and rangeland grasses, sedges, rushes, forbs, shrubs, and trees of Oregon, Washington, and Idaho. The code expedites recording of vegetation inventory data and is especially useful to those processing their data by contemporary computer systems. Editorial and secretarial personnel will find the name and authorship lists to be handy desk references.

KEYWORDS: Plant nomenclature, vegetation survey, Oregon, Washington, Idaho.

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INTRODUCTION
TO FOURTH EDITION

Brief, and easily translated, alpha symbols are now the accepted "language" or code for use by vegetation scientists and those inventorying resources of forest and rangeland. These symbols greatly facilitate entering plant species identification on field sheets and assist subsequent computer compilation and analysis of vegetation data. Standardization of the symbol list among agencies and colleges within a multistate area makes it easier to adapt college students to summer fieldwork of several agencies and makes feasible the pooling of vegetation data from various institutions, agencies, and locations in a region. The code system presented here is accepted usage for many government agencies and university research workers in Oregon, Washington, and Idaho.

Features and Additions

This fourth edition of plant coding for Oregon, Washington, and Idaho now updates the listings with hundreds of additional plant names and has been checked against the latest taxonomic works for the three-State area. The current listing maintains the basic four-letter system of symbol selection with the following standard variations:

(1) A single digit number appears as a suffix to the alpha symbol for certain species to resolve potential duplication of symbols.

(2) A fifth letter is part of most symbols which designate a genus without indicating species, and a fifth letter also appears in those instances where a varietal name is appended to the genus and species.

(3) Some genera symbols consist of four letters or less, e.g., ACER, AIRA, GEUM, IRIS, POA, RHUS, ROSA.

In preparation for this edition an attempt was made to meet the requests of several users of the list for additional common names. Searches for these vernacular terms were not always successful; indeed, some plants have not as yet acquired an English language label and a blank follows the = sign.

A completely new feature of this listing is a notation of authorship of each scientific name, done in the form prescribed by the International Rules of Botanical Nomenclature. This tabulation should be a speedy reference source for scientists, technicians, writers, editors, and advanced students.

Partitioning of the plant symbol list by growth form is retained in this edition, i.e., separate sections for grasses, grasslike plants (sedges and rushes), forbs, shrubs, and trees. Workers needing growth-form designators for computer work will find this problem best handled by adding a numeric code on the basic data sheet such as the field plot form. A number can be added just ahead of each alpha symbol by using the following scheme:

1 = Grass

2 = Grasslike plant

3 = Forb (broad-leaved herbs plus ferns and allied families)

4 = Shrub

5 = Tree

6 = Moss

A section is again provided for locating new valid names of species whose old names have dropped into synonymity. The user of the publication is alerted about synonyms by a numeric code on the far right side of each page of tabular material, and it instructs the reader thus:

1 = Name listed is a synonym, new name will be found in the synonymy section under the same genus; only the species name has changed.

2 = Name listed is a synonym, new valid name will be found in the synonymy section with a shift in genus shown.

Blank = Name listed is valid.

Almost all of the synony problems involved in using this listing could be eliminated if main dependence for species identification is on the single volume "Flora of the Pacific Northwest" or the five-volume work, "Vascular Plants of the Pacific Northwest." But if the user of the code list lacks either of these works by C. Leo Hitchcock et al., the synonym list is very helpful.

Generally, scientific names in the edition were verified in the following publications:

Hitchcock, A. S.
1950. Manual of the grasses of the United States. Ed. 2 (revised by Agnes Chase). U.S. Department of Agriculture Miscellaneous Publication 200.

Hitchcock, C. Leo, Arthur Cronquist, Marion Owenby, and J. W. Thompson.
1955-69. Vascular plants of the Pacific Northwest. Parts 1-5. University of Washington Press, Seattle.

Hitchcock, C. Leo, and Arthur Cronquist.
1973. Flora of the Pacific Northwest. University of Washington Press, Seattle.

Little, Elbert L., Jr.
1953. Check list of native and naturalized trees of the United States (including Alaska). U.S. Department of Agriculture Handbook No. 41.

There were some plant species in southeast and southwest portions of the province which were not covered by Hitchcock et al. In these instances, other manuals were consulted such as:

Munz, Philip A., and David D. Keck.
1970. A flora of California. University of California Press, Berkeley.

Davis, Ray J.
1952. Flora of Idaho. William C. Brown Co., Dubuque, Iowa.

Four subspecies were added to the woody group of sagebrush (*Artemisia* spp.) by A. H. Winward, using the sagebrush classification scheme of Beetle and Young, which was developed in their publications:

Beetle, A. A.
1960. A study of sagebrush: The section *tridentata* of *Artemisia*. Wyoming Agricultural Experiment Station Bulletin 368.

Beetle, A. A., and A. Young.
1965. A third subspecies in the *Artemisia tridentata* complex. Rhodora 67: 405-406.

Inquiries

The lists of species shown here plus some supplementary information are stored in the files of the Oregon State University Computer Center; thus there are extracts and combinations of information from the stored material which are available as computer printouts at nominal fees. These special listings are:

1. Scientific names in alphabetical order without respect to the growth form grouping or sequence of symbols.
2. Scientific names with listing controlled by alphabetical order of the alpha symbols.
3. Listing by common names in alphabetical order.
4. A limited listing of just those species whose alpha symbols carry a numeric suffix, the tie breaker.

Another option is change of format from this publication to one with any computer data field listed singly or in most any combination or order across the page. Requests for these compilations should be made to the Rangeland Resources Program, Oregon State University, Corvallis, Oregon 97331.

From time to time this plant symbol list will be revised to meet changes and advances in plant taxonomy. The Pacific Northwest Forest and Range Experiment Station and Oregon State University, which hold the master data and program for assigning plant symbols, will make these revisions. They will also welcome suggestions about addition of new species and the location of possible errors in the current listings.

History of Plant Code Development

Genesis of plant codes for recording vegetation studies of forests and rangelands is traceable back to 1912 and involves several notable plant ecologists. This interesting history is given in the introduction to the third edition, entitled, "Northwest Range Plant Symbols." It was published in 1967 by the Pacific Northwest Forest and Range Experiment Station as Research Paper PNW-40. Supply of the third edition is exhausted, although file copies may be seen at certain libraries.

MASTER LIST
OF SPECIES AND SYMBOLS

Grasses

SPEC. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SYN. CODE
AEGIL	AEGILOPS			L.	=GOATGRASS	
AECY	AEGILOPS	CYLINDRICA		HOST	=	
AGROP	AGROPYRON			GAERTN.	=WHEATGRASS	
AGAM	AGROPYRON	AMURENSE		DROBOV	=AMUR WHEATGRASS	
AGCA	AGROPYRON	CANINUM		(L.) BEAUV.	=CUTTING WHEATGRASS	
AGCAA	AGROPYRON	CANINUM	ANDINUM	(SCRIBN. & SMITH) C. L. HITCHC.	=	
AGCAC	AGROPYRON	CANINUM	CANINUM	(L.) BEAUV.	=	
AGCAM	AGROPYRON	CANINUM	MAJUS	(VASEY) C. L. HITCHC.	=	
AGCR	AGROPYRON	CRISTATUM		(L.) GAERTN.	=FAIRWAY CRESTED WHEATGRASS	
AGDA	AGROPYRON	DASYSTACHYUM		(HOOK.) SCRIBN.	=THICKSPIKE WHEATGRASS	
AGDE	AGROPYRON	DESERTORUM		SCHULT.	=STANDARD CRESTED WHEATGRASS	
AGEL	AGROPYRON	ELONGATUM		HOST. EX BEAUV.	=TALL WHEATGRASS	
AGIN	AGROPYRON	INERME		RYDB.	=BEARDLESS BLUEBUNCH WHEATGRASS	1
AGIN 2	AGROPYRON	INTERMEDIUM		(HOST.) BEAUV.	=INTERMEDIATE WHEATGRASS	
AGPU	AGROPYRON	PUNGENS		(PERS.) R. & S.	=STIFFLEAF QUACKGRASS	
AGRE	AGROPYRON	REPENS		(L.) BEAUV.	=QUACKGRASS	
AGRI	AGROPYRON	RIPARIUM		SCRIBN. & SMITH	=STREAMBANK WHEATGRASS	1
AGSA	AGROPYRON	SAXICOLA		PIPER	=FOXTAIL WHEATGRASS	1
AGSC 2	AGROPYRON	SCRIBNERI		VASEY	=	
AGSI	AGROPYRON	SIBIRICUM		BEAUV.	=SIBERIAN WHEATGRASS	1
AGSM	AGROPYRON	SMITHII		RYDB.	=WESTERN WHEATGRASS; BLUESTEM WHEATGRASS	
AGSP	AGROPYRON	SPICATUM		(PURSH) SCRIBN. & SMITH	=BEARDED BLUEBUNCH WHEATGRASS	
AGSU	AGROPYRON	SUBSECUNDUM		A.S.HITCHC	=BEARDED WHEATGRASS	1
AGSUA	AGROPYRON	SUBSECUNDUM	ANDINUM	(SCRIBN. & SM.) A.S.HITCHC.	=ALPINE BEARDED WHEATGRASS	1
AGTR	AGROPYRON	TRACHYCAULUM		(LINK) MALTE.	=SLENDER WHEATGRASS	1
AGTR 2	AGROPYRON	TRICHOPHORUM		C. RICHT.	=PUBESCENT WHEATGRASS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
AGTR 3	AGROPYRON	TRITICEUM		GAERTN. =	
AGROS	AGROSTIS			L. =BENTGRASS	
AGAE	AGROSTIS	AEQUIVALVIS		(TRIN.) TRIN. =ALASKA BENTGRASS	
AGAL	AGROSTIS	ALBA		L. =REDTOP	
AGAS	AGROSTIS	ASPERA		MICHX. =	2
AGDI	AGROSTIS	DIEGOENSIS		VASEY =THIN BENTGRASS	
AGEX	AGROSTIS	EXARATA		TRIN. =SPIKE BENTGRASS	
AGHA	AGROSTIS	HALLII		VASEY =HALLS BENTGRASS	
AGHI	AGROSTIS	HIEMALIS		OF AUTHORS NOT (WALT.) B. S. P. =WINTER BENTGRASS	1
AGHIG	AGROSTIS	HIEMALIS	GEMINATA	A. S. HITCHC. =ARCTIC WINTER BENTGRASS	1
AGHO	AGROSTIS	HOWELLII		SCRIBN. =	
AGHU	AGROSTIS	HUMILIS		VASEY =ALPINE BENTGRASS	
AGID	AGROSTIS	IDAHOENSIS		NASH =	
AGIN 3	AGROSTIS	INTERRUPTA		L. =	
AGLO	AGROSTIS	LONGILIGULA		A. S. HITCHC. =PACIFIC BENT-GRASS	
AGMI	AGROSTIS	MICROPHYLLA		STEUD. =	
AGOR	AGROSTIS	OREGONENSIS		VASEY =OREGON BENTGRASS	
AGPA 2	AGROSTIS	PALLENS		TRIN. =DUNE BENTGRASS	
AGPA	AGROSTIS	PALUSTRIS		HUDS. =CREEPING BENTGRASS	1
AGRA	AGROSTIS	RACEMOSA		MICHX. =	2
AGRO	AGROSTIS	ROSSIAE		VASEY =ROSS BENTGRASS	
AGSC	AGROSTIS	SCABRA		WILLD. =WINTER BENTGRASS	
AGSE	AGROSTIS	SEMIVERTICILLATA		(FORSK.) CHRIST. =WATER BENTGRASS	
AGSP 2	AGROSTIS	SPICA-VENTI		L. =	
AGTE	AGROSTIS	TENUIS		SIBTH. =COLONIAL BENTGRASS	
AGTH	AGROSTIS	THURBERIANA		A. S. HITCHC. =THURBER BENTGRASS	

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                                                                                  COMMON NAME
AGVA    AGROSTIS        VARIABILIS                          RYDB.
                                                              =
AIRA    AIRA                                                L.
                                                              =HAIRGRASS
AICA    AIRA            CARYOPHYLLEA                        L.
                                                              =SILVER HAIRGRASS
AIEL    AIRA            ELEGANS                             WILLD. EX GAUDIN
                                                              =
AIOB    AIRA            OBTUSATA                            MICHX.                                           2
                                                              =
AIPR    AIRA            PRAECOX                             L.
                                                              =EARLY HAIRGRASS
ALOPE   ALOPECURUS                                          L.
                                                              =MEADOW FOXTAIL
ALAE    ALOPECURUS      AEQUALIS                            SOBOL.
                                                              =SHORTAWN FOXTAIL
ALAL 2  ALOPECURUS      ALPINUS                             J. E. SMITH
                                                              =
ALAR    ALOPECURUS      ARUNDINACEUS                        POIR.
                                                              =REED FOXTAIL
ALCA 2  ALOPECURUS      CAROLINIANUS                        WALT.
                                                              =
ALGE    ALOPECURUS      GENICULATUS                         L.
                                                              =WATER FOXTAIL
ALHO    ALOPECURUS      HOWELLII                            VASEY                                            1
                                                              =HOWELL FOXTAIL
ALPR    ALOPECURUS      PRATENSIS                           L.
                                                              =MEADOW FOXTAIL
ALSA    ALOPECURUS      SACCATUS                            VASEY
                                                              =
AMMOP   AMMOPHILA                                           HOST
                                                              =BEACHGRASS
AMAR    AMMOPHILA       ARENARIA                            (L.) LINK
                                                              =EUROPEAN BEACHGRASS
ANDRO2  ANDROPOGON                                          L.
                                                              =BLUESTEM
ANSC    ANDROPOGON      SCOPARIUS                           MICHX.
                                                              =
ANTHO   ANTHOXANTHUM                                        L.
                                                              =VERNALGRASS
ANAR 4  ANTHOXANTHUM    ARISTATUM                           BOIS.
                                                              =ANNUAL VERNALGRASS
ANOD    ANTHOXANTHUM    ODORATUM                            L.
                                                              =SWEET VERNALGRASS
ARIST   ARISTIDA                                            L.
                                                              =THREEAWN
ARGL 2  ARISTIDA        GLAUCA                              (NEES) WALP.
                                                              =REVENCHON THREEAWN
ARLO 3  ARISTIDA        LONGISETA                           STEUD.
                                                              =
ARLOR   ARISTIDA        LONGISETA         ROBUSTA           MERRILL
                                                              =RED THREEAWN
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SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
AROL	ARISTIDA	OLIGANTHA		MICHX.	=PRAIRIE THREEAWN	
ARWR	ARISTIDA	WRIGHTII		NASH.	=WRIGHT THREEAWN	
ARRHE	ARRHENATHERUM			BEAUV.	=OATGRASS	
AREL	ARRHENATHERUM	ELATIUS		(L.) PRESL.	=TALL OATGRASS	
AVENA	AVENA			L.	=OAT	
AVBA	AVENA	BARBATA		BROT.	=	
AVDU	AVENA	DUBIA		LEERS	=	2
AVFA	AVENA	FATUA		L.	=WILD OAT	
BECKM	BECKMANNIA			HOST	=SLOUGHGRASS	
BESY	BECKMANNIA	SYZIGACHNE		(STEUD.) FERN.	=AMERICAN SLOUGHGRASS	
BOUTE	BOUTELOUA			LAG.	=GRAMAGRASS	
BOGR	BOUTELOUA	GRACILIS		(H.B.K.) LAG. EX STEUD.	=BLUE GRAMA	
BRDI	BRACHYPODIUM	DISTACHYON		(L.) BEAUV.	=	
BRSY	BRACHYPODIUM	SYLVATICUM		(HUDS.) BEAUV.	=	
BRIZA	BRIZA			L.	=QUAKINGGRASS	
BRMA 2	BRIZA	MAXIMA		L.	=BIG QUAKINGGRASS	
BRMI	BRIZA	MINOR		L.	=LITTLE QUAKINGGRASS	
BROMU	BROMUS			L.	=BROME	
BRAN	BROMUS	ANOMALUS		RUPR.	=	
BRAR	BROMUS	ARENARIUS		LABILL.	=AUSTRALIAN BROME	
BRBR 2	BROMUS	BREVIARISTATUS		THURB.	=SLIMLEAF BROME	↱ 1
BRBR	BROMUS	BRIZAEFORMIS		FISCH. & MEY.	=RATTLE BROME	
BRCA	BROMUS	CARINATUS		H. & A.	=CALIFORNIA BROME	
BRCAM	BROMUS	CARINATUS	MARITIMUS	(PIPER) C. L. HITCHC.	=	
BRCI	BROMUS	CILIATUS		L.	=FRINGED BROME	
BRCO	BROMUS	COMMUTATUS		SCHRAD.	=HAIRY BROME	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
BRER	BROMUS	ERECTUS		HUDS. =MEADOW BROME	
BRIN	BROMUS	INERMIS		LEYS. =SMOOTH BROME	
BRINP	BROMUS	INERMIS	PUMPELLIANUS	(SCRIBN.) WAGNON =	
BRJA	BROMUS	JAPONICUS		THUNB. =JAPANESE BROME	
BRLA	BROMUS	LAEVIPES		SHEAR =CHINOOK BROME	1
BRMA 4	BROMUS	MACROSTACHYS		DESF. =MEDITERRANEAN BROME	
BRMA 3	BROMUS	MADRITENSIS		L. =SPANISH BROME	
BRMA	BROMUS	MARGINATUS		NEES =MOUNTAIN BROME	1
BRMO	BROMUS	MOLLIS		L. =SOFT BROME	
BROR	BROMUS	ORCUTTIANUS		VASEY =ORCUTT BROME	
BRPA	BROMUS	PACIFICUS		SHEAR =	
BRPU 2	BROMUS	PUMPELLIANUS		SCRIBN. =PUMPELLY BROME	1
BRRA	BROMUS	RACEMOSUS		L. =BALD BROME	1
BRRI	BROMUS	RIGIDUS		ROTH. =RIPGUT BROME	
BRRU	BROMUS	RUBENS		L. =FOXTAILBROME RED BROME	
BRSE	BROMUS	SECALINUS		L. =CHESS BROME	
BRSI	BROMUS	SITCHENSIS		TRIN. =	
BRSIA	BROMUS	SITCHENSIS	ALEUTENSIS	(TRIN.) HULTEN =	
BRSIS	BROMUS	SITCHENSIS	SITCHENSIS	TRIN. =	
BRST	BROMUS	STERILIS		L. =	
BRSU	BROMUS	SUKSDORFII		VASEY =SUKSDORF BROME	
BRTE	BROMUS	TECTORUM		L. =CHEATGRASS BROME	
BRTEG	BROMUS	TECTORUM	GLABRATUS	SPENNER =	1
BRTO	BROMUS	TOMENTELLUS		BOISS. =RUSSIAN BROME	
BRTR	BROMUS	TRINII		DESV. =CHILEAN BROME	
BRVU	BROMUS	VULGARIS		(HOOK.) SHEAR =COLUMBIA BROME	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
CALAM	CALAMAGROSTIS			ADANS.	=REEDGRASS	
CABR 7	CALAMAGROSTIS	BREWERI		THURB.	=	
CACA 6	CALAMAGROSTIS	CALIFORNICA		KEARN.	=SIERRA REEDGRASS	
CACA	CALAMAGROSTIS	CANADENSIS		(MICHX.) BEAUV.	=BLUEJOINT REEDGRASS	
CACAA	CALAMAGROSTIS	CANADENSIS	ACUMINATA	VASEY	=	
CACAI	CALAMAGROSTIS	CANADENSIS	IMBERBIS	(STEBBINS) C. L. HITCHC.	=	
CACAL	CALAMAGROSTIS	CANADENSIS	LACTEA	(BEAL) C. L. HITCHC.	=	
CACAM	CALAMAGROSTIS	CANADENSIS	MACOUNIANA	(VASEY) STEBBINS	=	
CACAP	CALAMAGROSTIS	CANADENSIS	PALLIDA	(VASEY & SCRIBN.) STEBBINS	=	
CACAR	CALAMAGROSTIS	CANADENSIS	ROBUSTA	VASEY	=	
CACAS	CALAMAGROSTIS	CANADENSIS	SCABRA	(KUNTH) A. S. HITCHC.	=	
CACR 5	CALAMAGROSTIS	CRASSIGLUMIS		THRUB.	=	
CAHO 2	CALAMAGROSTIS	HOWELLII		VASEY	=	
CAIN	CALAMAGROSTIS	INEXPANSA		GRAY	=NORTHERN REEDGRASS	
CAKO	CALAMAGROSTIS	KOELERIOIDES		VASEY	=FIRE REEDGRASS	
CANE 3	CALAMAGROSTIS	NEGLECTA		(EHRH.) GAERTN.	=SLIMSTEM REEDGRASS	
CANU 3	CALAMAGROSTIS	NUTKAENSIS		(PRESL.) STEUD.	=PACIFIC REEDGRASS	
CAPU	CALAMAGROSTIS	PURPURASCENS		R. BR.	=PURPLE PINEGRASS	
CARU	CALAMAGROSTIS	RUBESCENS		BUCKL.	=PINEGRASS	
CASE 2	CALAMAGROSTIS	SESQUIFLORA		(TRIN.) KAWANO	=	
CATW	CALAMAGROSTIS	TWEEDYI		(SCRIBN.) SCRIBN.	=CASCADES REEDGRASS	
CATAB	CATABROSA			BEAUV.	=BROOKGRASS; WATER WHORLWORT	
CAAQ 2	CATABROSA	AQUATICA		(L.) BEAUV.	=	
CENCH	CENCHRUS			L.	=SANDBUR; BURGRASS; HEDGEHOG-GRASS	
CELO	CENCHRUS	LONGISPINUS		(HACK.) FERN.	=	
CINNA	CINNA			L.	=WOODREED GRASS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
CILA 2	CINNA	LATIFOLIA		(TREVIR.) GRISEB. =DROOPING WOODREED	
COLEA	COLEANTHUS			SEIDEL =MOSS-GRASS	
COSU 2	COLEANTHUS	SUBTILIS		(TRATT.) SEIDEL =	
CORYN	CORYNEPHORUS			BEAUV. =GRAY HAIRGRASS	
COCA 6	CORYNEPHORUS	CANESCENS		(L.) BEAUV. =	
CYNOD	CYNODON			RICH. =CYNODON	
CYDA	CYNODON	DACTYLON		(L.) PERS. =	
CYNOS	CYNOSURUS			L. =DOGTAIL	
CYCR	CYNOSURUS	CRISTATUS		L. =CRESTED DOGTAIL	
CYEC	CYNOSURUS	ECHINATUS		L. =HEDGEHOG DOGTAIL	
DACTY	DACTYLIS			L. =ORCHARDGRASS; COCK≠S-FOOT GRASS	
DAGL	DACTYLIS	GLOMERATA		L. =ORCHARDGRASS; COCK≠S-FOOT GRASS	
DANTH	DANTHONIA			DC. =DANTHONIA	
DACA	DANTHONIA	CALIFORNICA		BOLAND. =CALIFORNIA DANTHONIA	
DACAA	DANTHONIA	CALIFORNICA	AMERICANA	(SCRIBN.) A.S.HITCHC. =HAIRY CALIFORNIA DANTHONIA	
DACAC	DANTHONIA	CALIFORNICA	CALIFORNICA	BOLAND. =CALIFORNIA DANTHONIA	
DAIN	DANTHONIA	INTERMEDIA		VASEY =TIMBER DANTHONIA	
DASP	DANTHONIA	SPICATA		(L.) BEAUV. EX R. & S. =	
DAUN	DANTHONIA	UNISPICATA		(THURB.) MUNRO EX MACCLN =ONESPIKE DANTHONIA	
DESCH	DESCHAMPSIA			BEAUV. =HAIRGRASS	
DEAT	DESCHAMPSIA	ATROPURPUREA		(WAHLENB.) SCHEELE =MOUNTAIN HAIRGRASS	
DECA	DESCHAMPSIA	CAESPITOSA		(L.) BEAUV. =TUFTED HAIRGRASS	
DEDA	DESCHAMPSIA	DANTHONIOIDES		(TRIN.) MUNRO EX BENTH. =ANNUAL HAIRGRASS	
DEEL	DESCHAMPSIA	ELONGATA		(HOOK.) MUNRO EX BENTH. =SLENDER HAIRGRASS	
DIGIT	DIGITARIA			HIEST. =CRABGRASS	
DIIS	DIGITARIA	ISCHAEMUM		(SCHREB.) SCHREB. EX MUHL. =SMOOTH CRABGRASS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
DISA	DIGITARIA	SANGUINALIS		(L.) SCOP. =HAIRY CRABGRASS	
DISTI	DISTICHLIS			RAF. =SALTGRASS	
DISP	DISTICHLIS	SPICATA		(L.) GREENE =SEASHORE SALTGRASS	
DIST	DISTICHLIS	STRICTA		(TORR.) RYDB. =DESERT SALTGRASS	
DISTD	DISTICHLIS	STRICTA	DENTATA	(RYDB.) C. L. HITCHC. =	
EAIN	EATONIA	INTERMEDIA		RYDB. =	2
ECHIN	ECHINOCHLOA			BEAUV. =COCKSPUR	
ECCR	ECHINOCHLOA	CRUSGALLI		(L.) BEAUV. =BARNYARDGRASS	
ECCRF	ECHINOCHLOA	CRUSGALLI	FRUMENTACEA	W. F. WIGHT =JAPANESE MILLET	1
ELYMU	ELYMUS			L. =WILDRYE	
ELAM	ELYMUS	AMBIGUUS		VASEY & SCRIBN. =	
ELAMA	ELYMUS	AMBIGUUS	AMBIGUUS	VASEY & SCRIBN. =	
ELAMS	ELYMUS	AMBIGUUS	SALMONIS	C. L. HITCHC. =	
ELAR	ELYMUS	ARENICOLA		PILGER =SAND WILDRYE	1
ELAR 2	ELYMUS	ARISTATUS		MERRILL =PURPLE WILDRYE	
ELBR	ELYMUS	BREVIFOLIUS		M. E. JONES =	2
ELCA	ELYMUS	CANADENSIS		L. =CANADA WILDRYE	
ELCA 2	ELYMUS	CAPUT-MEDUSAE		L. =MEDUSAHEAD WILDRYE	
ELCI	ELYMUS	CINEREUS		SCRIBN. & MERRILL =GIANT WILDRYE	
ELCIP	ELYMUS	CINEREUS	PUBENS	(PIPER) C. L. HITCHC. =	
ELCO	ELYMUS	CONDENSATUS		PRESL. =	1
ELFL	ELYMUS	FLAVESCENS		SCRIBN. & SMITH =	
ELGI	ELYMUS	GIGANTEUS		VAHL =	
ELGL	ELYMUS	GLAUCUS		BUCKL. =BLUE WILDRYE	
ELGLG	ELYMUS	GLAUCUS	GLAUCUS	BUCKL. =BLUE WILDRYE	
ELGLJ	ELYMUS	GLAUCUS	JEPSONI	DAVY =JEPSON WILDRYE	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
ELHI	ELYMUS	HIRSUTUS		PRESL	=	
ELJU	ELYMUS	JUNCEUS		FISCH.	=RUSSIAN WILDRYE	
ELMA 2	ELYMUS	MACOUNI		VASEY	=MACOUN WILDRYE	
ELMO	ELYMUS	MOLLIS		TRIN.	=COMMON DUNE WILDRYE	
ELTR	ELYMUS	TRITICOIDES		BUCKL.	=CREEPING WILDRYE	
ELVI	ELYMUS	VIRGINICUS		L.	=	
ERAGR	ERAGROSTIS			HOST	=LOVEGRASS	
ERCI 2	ERAGROSTIS	CILIANENSIS		(ALLIONI) MOSHER	=STINKGRASS	
ERHY	ERAGROSTIS	HYPNOIDES		(LAM.) B. S. P.	=	
ERLU	ERAGROSTIS	LUTESCENS		SCRIBN.	=	
ERMU	ERAGROSTIS	MULTICAULIS		STEUD.	=	
EROR 2	ERAGROSTIS	ORCUTTIANA		VASEY	=	
ERPE 3	ERAGROSTIS	PECTINACEA		(MICHX.) NEES	=	
ERGRC	ERYTHRONIUM	GRANDIFLORUM	CANDIDUM	(PIPER) ABRAMS	=	
ERGRN	ERYTHRONIUM	GRANDIFLORUM	NUDIPETALUM	(APPLEGATE) C. L. HITCHC.	=	
ERNU 2	ERYTHRONIUM	NUDOPETALUM		APPLEGATE	=	1
ERRE 2	ERYTHRONIUM	REVOLUTUM		SMITH	=	
FESTU	FESTUCA			L.	=FESCUE	
FEAR 2	FESTUCA	ARIDA		ELMER	=DESERT FESCUE	1
FEAR	FESTUCA	ARIZONICA		VASEY	=ARIZONA FESCUE	
FEAR 3	FESTUCA	ARUNDINACEA		SCHREB.	=REED FESCUE	
FEBR	FESTUCA	BROMOIDES		L.	=	
FECA	FESTUCA	CALIFORNICA		VASEY	=CALIFORNIA FESCUE	
FEDE	FESTUCA	DERTONENSIS		(ALL.) ASCH. & GRAEBN.	=BROME FESCUE	1
FEFL	FESTUCA	ELATIOR		L.	=MEADOW FESCUE	1
FEGR	FESTUCA	GRAYI		(ABRAMS) PIPER	=GRAYS FESCUE	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
FEID	FESTUCA	IDAHOENSIS		ELMER =IDAHO FESCUE	
FEIDO	FESTUCA	IDAHOENSIS	OREGONA	(HACK.) C. L. HITCHC. =	
FEME	FESTUCA	MEGALURA		NUTT. =FOXTAIL FESCUE	
FEMI	FESTUCA	MICROSTACHYS		NUTT. =SMALL FESCUE	
FEMY	FESTUCA	MYUROS		L. =RATTAIL FESCUE	
FEOC	FESTUCA	OCCIDENTALIS		WALT. =WESTERN FESCUE	
FEOC 2	FESTUCA	OCTOFLORA		WALT. =SIXWEEKS FESCUE	
FEOV	FESTUCA	OVINA		L. =SHEEP FESCUE	
FEOVB	FESTUCA	OVINA	BRACHYPHYLLA	WATS. =ALPINE FESCUE	1
FEOVO	FESTUCA	OVINA	OVINA	L. =SHEEP FESCUE	
FEPA	FESTUCA	PACIFICA		PIPER =PACIFIC FESCUE	1
FEPR	FESTUCA	PRATENSIS		HUDS. =	
FERE	FESTUCA	REFLEXA		BUCKL. =TWOFLOWER FESCUE	1
FERU	FESTUCA	RUBRA		L. =RED FESCUE	
FERUC	FESTUCA	RUBRA	COMMUTATA	GAUDIN =CHEWINGS FESCUE	1
FERUR	FESTUCA	RUBRA	RUBRA	L. =RED FESCUE	
FERUS	FESTUCA	RUBRA	STOLONIFERA	MIEGEV. =CREEPING RED FESCUE	
FESC	FESTUCA	SCABRELLA		TORR. =ROUGH FESCUE	
FESU	FESTUCA	SUBULATA		TRIN. =BEARDED FESCUE	1
FESU 2	FESTUCA	SUBULIFLORA		SCRIBN. =CRINKLEAWN FESCUE	
FEVI	FESTUCA	VIRIDULA		VASEY =GREEN FESCUE	
GASTR	GASTRIDIUM			BEAUV. =NITGRASS	
GAVE 2	GASTRIDIUM	VENTRICOSUM		(GOUAN.) SCHINZ & THELL. =NITGRASS	
GLYCE	GLYCERIA			R. BR. =MANNAGRASS	
GLBO	GLYCERIA	BOREALIS		(NASH) BATCHELDER =NORTHERN MANNAGRASS	
GLEL	GLYCERIA	ELATA		(NASH) M. E. JONES =TALL MANNAGRASS	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
GLGR	GLYCERIA	GRANDIS		WATS. EX GRAY	=AMERICAN MANNAGRASS	
GLLE 3	GLYCERIA	LEPTOSTACHYA		BUCKL.	=	
GLOC	GLYCERIA	OCCIDENTALIS		(PIPER) J. C. NELS.	=	
GLPA	GLYCERIA	PAUCIFLORA		PRESL.	=WEAK MANNAGRASS	1
GLST	GLYCERIA	STRIATA		(LAM.) A. S. HITCHC.	=FOWL MANNAGRASS	
HESPE2	HESPEROCHLOA			RYDB.	=SPIKEFESCUE	
HEKI	HESPEROCHLOA	KINGII		(WATS.) RYDB.	=	
HIERO	HIEROCHLOE			R. BR.	=SWEETGRASS	
HIOC	HIEROCHLOE	OCCIDENTALIS		BUCKL.	=CALIFORNIA SWEETGRASS	
HIOD	HIEROCHLOE	ODORATA		(L.) BEAUV.	=	
HOLCU	HOLCUS			L.	=VELVETGRASS	
HOLA	HOLCUS	LANATUS		L.	=COMMON VELVETGRASS	
HOMO	HOLCUS	MOLLIS		L.	=	
HORDE	HORDEUM			L.	=BARLEY	
HOBR	HORDEUM	BRACHYANTHERUM		NEVSKI	=NORTHERN MEADOW BARLEY	
HOBU	HORDEUM	BULBOSUM		L.	=BULBOUS BARLEY	
HODE 2	HORDEUM	DEPRESSUM		(SCRIBN. & SM.) RYDB.	=MEADOW BARLEY	
HOGE	HORDEUM	GENICULATUM		ALLIONI	=	
HOGL 2	HORDEUM	GLAUCUM		STEUD.	=	
HOGU	HORDEUM	GUSSONIANUM		PARL.	=	1
HOHY	HORDEUM	HYSTRIX		ROTH.	=MEDITERRANEAN BARLEY	
HOJU	HORDEUM	JUBATUM		L.	=FOXTAIL BARLEY	
HOLE	HORDEUM	LEPORINUM		LINK	=	
HOMU	HORDEUM	MURINUM		L.	=MOUSE BARLEY	
HONO	HORDEUM	NODOSUM		AUTHORS NOT L.	=	1
HONOB	H[illegible]M	NODOSUM	BOREALE	A. S. HITCHC.	=	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME
HOPU	HORDEUM	PUSILLUM		NUTT.	=
KOELE	KOELERIA			PERS.	=KOELERIA
KOCR	KOELERIA	CRISTATA		PERS.	=PRAIRIE JUNEGRASS
LAGUR	LAGURUS			L.	=HARESTAIL
LAOV	LAGURUS	OVATUS		L.	=
LEERS	LEERSIA			SOLAND.	=CUTGRASS
LEOR	LEERSIA	ORYZOIDES		(L.) SWARTZ	=
LEPTO3	LEPTOCHLOA			BEAUV.	=STRANGLETOP
LEFA	LEPTOCHLOA	FASCICULARIS		(LAM.) GRAY	=
LOLIU	LOLIUM			L.	=RYEGRASS
LOMU	LOLIUM	MULTIFLORUM		LAM.	=ITALIAN RYEGRASS
LOPE 2	LOLIUM	PERENNE		L.	=PERENNIAL RYEGRASS
LORE	LOLIUM	REMOTUM		SCHRANK.	=HARDY RYEGRASS
LOTE	LOLIUM	TEMULENTUM		L.	=RYEGRASS
MELIC	MELICA			L.	=MELIC; ONIONGRASS
MEAR	MELICA	ARISTATA		THURB. EX BOLAND.	=BEARDED MELIC
MEBU	MELICA	BULBOSA		GEYER EX PORTER & COULT.	=ONIONGRASS
MEFU	MELICA	FUGAX		BOLAND.	=LITTLE ONIONGRASS
MEGE	MELICA	GEYERI		MUNRO	=GEYER ONIONGRASS
MEHA	MELICA	HARFORDII		BOLAND.	=HARFORD MELIC
MEIM	MELICA	IMPERFECTA		TRIN.	=CALIFORNIA MELIC
MESM	MELICA	SMITHII		(PORTER) VASEY	=SMITH MELIC
MESP	MELICA	SPECTABILIS		SCRIBN.	=SHOWY ONIONGRASS
MEST	MELICA	STRICTA		BOLAND.	=ROCK MELIC
MESU	MELICA	SUBULATA		(GRISEB.) SCRIBN.	=ALASKA ONIONGRASS
MESUP	MELICA	SUBULATA	PAMMELII	(SCRIBN.) C. L. HITCHC.	=

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
MUHLE	MUHLENBERGIA			SCHREB. =MUHLY	
MUAN	MUHLENBERGIA	ANDINA		(NUTT.) A. S. HITCHC. =FOXTAIL MUHLY	
MUAS	MUHLENBERGIA	ASPERIFOLIA		(NEES & MEY.) PARODI =ALKALI MUHLY	
MUCU	MUHLENBERGIA	CUSPIDATA		(TORR.) =	
MUFI	MUHLENBERGIA	FILIFORMIS		(THURB.) RYDB. =PULLUP MUHLY	
MUGL	MUHLENBERGIA	GLOMERATA		TRIN. =	1
MUJO	MUHLENBERGIA	JONESII		(VASEY) HITCHC. =MODOC MUHLY	
MUME	MUHLENBERGIA	MEXICANA		(L.) TRIN. =	
MUMI	MUHLENBERGIA	MINUTISSIMA		(STELD.) SWALLEN =	
MURA	MUHLENBERGIA	RACEMOSA		(MICHX.) B. S. P. =	
MURI	MUHLENBERGIA	RICHARDSONIS		(TRIN.) RYDB. =	
MUSQ	MUHLENBERGIA	SQUARROSA		RYDB. =MAT MUHLY	1
NARDU	NARDUS			L. =WIREBENT; MAT-GRASS; NARD	
NAST	NARDUS	STRICTA		L. =	
ORCUT	ORCUTTIA			VASEY =ORCUTTIA	
ORTE 2	ORCUTTIA	TENUIS		HITCHC. =	
ORYZO	ORYZOPSIS			MICHX. =RICEGRASS	
ORAS	ORYZOPSIS	ASPERIFOLIA		MICHX. =	
OREX	ORYZOPSIS	EXIGUA		THURB. =LITTLE RICEGRASS	
ORHE	ORYZOPSIS	HENDERSONI		VASEY =HENDERSON RICEGRASS	
ORHY	ORYZOPSIS	HYMENOIDES		(R. & S.) RICKER =INDIAN RICEGRASS	
ORSW	ORYZOPSIS	SWALLENII		HITCHCOCK & SPELLENBERG =	
ORWE	ORYZOPSIS	WEBBERI		(THURB.) BENTH. EX VASEY =WEBBER RICEGRASS	
PAOC	PANICULARIA	OCCIDENTALIS		PIPER =	
PANIC	PANICUM			L. =PANICUM; WITCHGRASS; PANICGRASS	
PACA	PANICUM	CAPILLARE		L. =COMMON WITCHGRASS	

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PACAC	PANICUM	CAPILLARE	CAPILLARE	L. =COMMON WITCHGRASS	
PACAO	PANICUM	CAPILLARE	OCCIDENTALE	RYDB. =CUSHION WITCHGRASS	
PADI	PANICUM	DICHOTOMIFLORUM		MICHX. =	
PAMI	PANICUM	MILIACEUM		L. =	
PAOC 2	PANICUM	OCCIDENTALE		SCRIBN. =	
PAPA 2	PANICUM	PACIFICUM		HITCHC. & CHASE =	1
PASC	PANICUM	SCRIBNERIANUM		NASH =	
PASPA	PASPALUM			L. =PASPALUM	
PADI 2	PASPALUM	DISTICHUM		L. =	
PENNI	PENNISETUM			BENTH. =PENNISETUM	
PECL	PENNISETUM	CLANDESTINUM		HOCHST. EX CHIOV. =KIKUYU GRASS	
PEGL 3	PENNISETUM	GLAUCUM		(L.) R. BR. =PEARLMILLET	
PHALA	PHALARIS			L. =CANARYGRASS	
PHAQ	PHALARIS	AQUATICA		L. =	
PHAR	PHALARIS	ARUNDINACEA		L. =REED CANARYGRASS	
PHCA	PHALARIS	CANARIENSIS		L. =CANARYGRASS	
PHCA 4	PHALARIS	CAROLINIANA		WALT. =CAROLINA CANARY-GRASS	
PHMI 2	PHALARIS	MINOR		RETZ. =	
PHPA	PHALARIS	PARADOXA		L. =	
PHLEU	PHLEUM			L. =TIMOTHY	
PHAL	PHLEUM	ALPINUM		L. =ALPINE TIMOTHY	
PHBO	PHLEUM	BOEHMERI		WIB. =	
PHPH	PHLEUM	PHLEOIDES		SIMONKAI =DRYLAND TIMOTHY	
PHPR	PHLEUM	PRATENSE		L. =TIMOTHY	
PHRAG	PHRAGMITES			TRIN. =REED	
PHCO	PHRAGMITES	COMMUNIS		(L.) TRIN. =COMMON REED	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
PLEUR	PLEUROPOGON			R. BR.	=SEMAPHOREGRASS	
PLDA	PLEUROPOGON	DAVYI		L.	=	
PLOR	PLEUROPOGON	OREGONUS		CHASE	=	
PLRE	PLEUROPOGON	REFRACTUS		(GRAY) BENTH.	=NODDING SEMAPHOREGRASS	
POA	POA			L.	=BLUEGRASS	
POAL	POA	ALPINA		L.	=ALPINE BLUEGRASS	
POAM	POA	AMPLA		MERRILL	=BIG BLUEGRASS	1
POAN	POA	ANNUA		L.	=ANNUAL BLUEGRASS	
POAR 2	POA	ARCTICA		AUTHORS NOT R. BR.	=ARCTIC BLUEGRASS	1
POBO	POA	BOLANDERI		VASEY	=BOLANDER BLUEGRASS	
POBU	POA	BULBOSA		L.	=BULBOUS BLUEGRASS	
POCA	POA	CANBYI		SCRIBN.	=CANBY BLUEGRASS	
POCO	POA	COMPRESSA		L.	=CANADA BLUEGRASS	
POCO 6	POA	CONFINIS		VASEY	=	
POCU 3	POA	CURTA		RYDB.	=	
POCU 4	POA	CURTIFOLIA		SCRIBN.	=	
POCU	POA	CUSICKII		VASEY	=CUSICK BLUEGRASS	
POCUE	POA	CUSICKII	EPILIS	(SCRIBN.) C. L. HITCHC.	=	
POCUP	POA	CUSICKII	PURPURASCENS	(BEAL) C. L. HITCHC.	=	
POEP	POA	EPILIS		SCRIBN.	=SKYLINE BLUEGRASS	1
POFE	POA	FENDLERIANA		(STEUD.) VASEY	=MUTTONGRASS	
POGL 6	POA	GLAUCIFOLIA		SCRIBN. & WILLIAMS	=	
POGR 4	POA	GRACILLIMA		(PIPER) C. L. HITCHC.	=	
POGRM	POA	GRACILLIMA	MULTNOMAE	(PIPER) C. L. HITCHC.	=	
POGR 5	POA	GRAYANA		VASEY	=	
POHO	POA	HOWELLII		VASEY & SCRIBN.	=HOWELL BLUEGRASS	

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POIN	POA	INTERIOR		RYDB.	=INLAND BLUEGRASS
POJU	POA	JUNCIFOLIA		SCRIBN.	=ALKALI BLUEGRASS
POLA 2	POA	LAXIFLORA		BUCKLEY	=
POLE 2	POA	LEIBERGII		SCRIBN.	=LEIBERG BLUEGRASS
POLE	POA	LEPTOCOMA		TRIN.	=BOG BLUEGRASS
POLEP	POA	LEPTOCOMA	PAUCISPICULA	(SCRIBN. & MERR.) C. L. HITCHC.	=
POLE 3	POA	LETTERMANI		VASEY	=LETTERMAN BLUEGRASS
POLO 3	POA	LONGIFOLIA		TRIN.	=
POLO	POA	LONGILIGULA		SCRIBN. & WILLIAMS	=LONGTONGUE MUTTON BLUEGRASS
POMA	POA	MACRANTHA		VASEY	=SEASHORE BLUEGRASS
POMA 3	POA	MARCIDA		A. S. HITCHC.	=
PONE 5	POA	NEMORALIS		L.	=
PONE	POA	NERVOSA		(HOOK.) VASEY	=WHEELER BLUEGRASS
PONEW	POA	NERVOSA	WHEELERI	(VASEY) C. L. HITCHC.	=
PONE 2	POA	NEVADENSIS		VASEY EX SCRIBN.	=NEVADA BLUEGRASS
POPA 6	POA	PACHYPHOLIS		PIPER	=
POPA	POA	PALUSTRIS		L.	=FOWL BLUEGRASS
POPA 7	POA	PATTERSONII		VASEY	=
POPR	POA	PRATENSIS		L.	=KENTUCKY BLUEGRASS
POPR 2	POA	PRINGLEI		AUTHORS NOT SCRIBN.	=PRINGLE BLUEGRASS
PORE	POA	REFLEXA		VASEY & SCRIBN.	=NODDING BLUEGRASS
PORH 2	POA	RHIZOMATA		HITCHC.	=SISKIYOU BLUEGRASS
PORU	POA	RUPICOLA		NASH.	=TIMBERLINE BLUEGRASS
POSA 3	POA	SANDBERGII		VASEY	=
POSC	POA	SCABRELLA		(THURB.) BENTH.	=PINE BLUEGRASS
POSE	POA	SECUNDA		AUTHORS NOT PRESL.	=SANDBERG BLUEGRASS

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POST	POA	STENANTHA		TRIN. =TRINIUS BLUEGRASS	
POSU	POA	SUKSDORFII		(BEAL) VASEY EX PIPER =	
POTR 3	POA	TRIVIALIS		L. =ROUGHSTALK BLUEGRASS	
POUN	POA	UNILATERALIS		SCRIBN. =SAN FRANCISCO BLUEGRASS	
POVA	POA	VASEYOCHLOA		SCRIBN. =OREGON BLUEGRASS	1
POLYP2	POLYPOGON			DESF. =POLYPOGON	
POGL 5	POLYPOGON	GLOMERATUS		WILLD. =	2
POIN 2	POLYPOGON	INTERRUPTUS		H. B. K. =DITCH POLYPOGON	
POMO	POLYPOGON	MONSPELIENSIS		(L.) DESF. =RABBITFOOT POLYPOGON	
PRHO	PROSARTES	HOOKERI		TORR. =	2
PUCCI	PUCCINELLIA			PARL. =ALKALIGRASS	
PUAI	PUCCINELLIA	AIROIDES		WATS. & COULT. =NUTTALL ALKALIGRASS	1
PUCU	PUCCINELLIA	CUSICKII		WEATHERBY =	
PUDI	PUCCINELLIA	DISTANS		(L.) PARL. =WEEPING ALKALIGRASS	
PULE	PUCCINELLIA	LEMMONI		(VASEY) SCRIBN. =LEMMON ALKALIGRASS	
PUMA	PUCCINELLIA	MARITIMA		(HUDS.) PARL. =	
PUNU	PUCCINELLIA	NUTTALLIANA		(SCHULT.) A. S. HITCHC. =	
PUPA	PUCCINELLIA	PAUCIFLORA		(PRESL.) MUNZ =	
PUPAH	PUCCINELLIA	PAUCIFLORA	HOLMII	(BEAL) C. L. HITCHC. =	
PUPAM	PUCCINELLIA	PAUCIFLORA	MICROTHECA	(BUCKL.) C. L. HITCHC. =	
PUPAP	PUCCINELLIA	PAUCIFLORA	PAUCIFLORA	(PRESL) MUNZ =	
PUPU	PUCCINELLIA	PUMILA		(VASEY) A. S. HITCHC. =	
SCLER	SCLEROCHLOA			BEAUV. =HARDGRASS	
SCDU	SCLEROCHLOA	DURA		(L.) BEAUV. =	
SCLER2	SCLEROPOA			GRISEB. =SCLEROPOA	
SCRI	SCLEROPOA	RIGIDA		(L.) GRISEB. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
SCOLO	SCOLOCHLOA			LINK	=SCOLOCHLOA	
SCFE	SCOLOCHLOA	FESTUCACEA		(WILLD.) LINK	=	
SCRIB	SCRIBNERIA			HACKEL	=SCRIBNER-GRASS	
SCBO	SCRIBNERIA	BOLANDERI		(THURB.) HACKEL	=	
SECE	SECALE	CEREALE		L.	=WINTER RYE	
SETAR	SETARIA			BEAUV.	=BRISTLEGRASS; FOXTAIL	
SELU	SETARIA	LUTESCENS		(WEIGEL) HUBB.	=YELLOW BRISTLEGRASS	
SEVE	SETARIA	VERTICILLATA		(L.) BEAUV.	=	
SEVI	SETARIA	VIRIDIS		(L.) BEAUV.	=GREEN BRISTLEGRASS	
SITAN	SITANION			RAF.	=SQUIRRELTAIL	
SIHA	SITANION	HANSENI		(SCRIBN.) J. G. SM.	=HANSEN SQUIRRELTAIL	
SIHO 2	SITANION	HORDEOIDES		(SUKSD.) C. L. HITCHC.	=	1
SIHY	SITANION	HYSTRIX		(NUTT.) J. G. SM.	=BOTTLEBRUSH SQUIRRELTAIL	
SIHYB	SITANION	HYSTRIX	BREVIFOLIUM	(J. G. SMITH) C. L. HITCHC.	=	
SIHYH	SITANION	HYSTRIX	HORDEOIDES	(SUKSD.) C. L. HITCHC.	=	
SIJU	SITANION	JUBATUM		J. G. SM.	=BIG SQUIRRELTAIL	
SILO 2	SITANION	LONGIFOLIUM		J. G. SMITH	=	1
SPART	SPARTINA			SCHREB.	=CORDGRASS	
SPAL	SPARTINA	ALTERNIFLORA		LOISEL.	=	
SPGR	SPARTINA	GRACILIS		TRIN.	=ALKALI CORDGRASS	
SPPE	SPARTINA	PECTINATA		LINK	=	
SPHEN2	SPHENOPHOLIS			SCRIBN.	=WEDGEGRASS; PRAIREGRASS	
SPIN	SPHENOPHOLIS	INTERMEDIA		(RYDB.) RYDB.	=	
SPOB	SPHENOPHOLIS	OBTUSATA		(MICHX.) SCRIBN.	=	
SPORO	SPOROBOLUS			R. BR.	=DROPSEED	
SPAI	SPOROBOLUS	AIROIDES		(TORR.) TORR.	=HAIR-GRASS DROPSEED	

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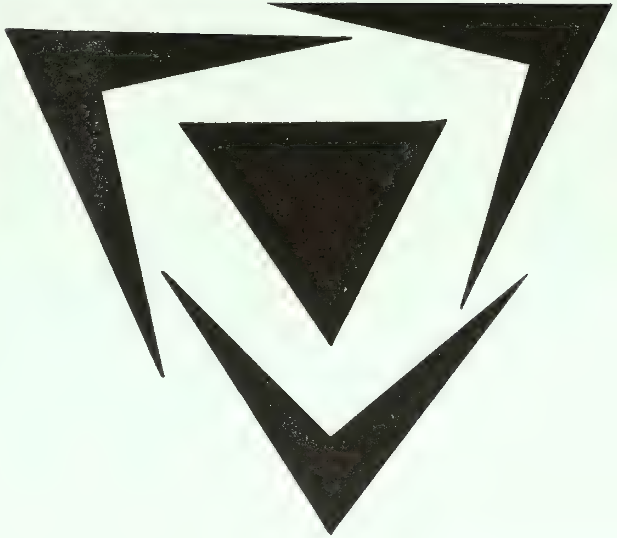
SPAS	SPOROBOLUS	ASPER		(MICHX.) KUNTH =	
SPCR	SPOROBOLUS	CRYPTANDRUS		(TORR.) GRAY =SAND DROPSEED	
SPMI	SPOROBOLUS	MICROSPERMUS		A. S. HITCHC. =	2
SPNE	SPOROBOLUS	NEGLECTUS		NASH =	
STIPA	STIPA			L. =NEEDLEGRASS	
STCA	STIPA	CALIFORNICA		MERR. & DAVY =PACIFIC NEEDLEGRASS	1
STCO	STIPA	COLUMBIANA		MACOUN =SUBALPINE NEEDLEGRASS	1
STCON	STIPA	COLUMBIANA	NELSONI	ST.JOHN =BIG SUBALPINE NEEDLEGRASS	1
STCO 2	STIPA	COMATA		TRIN. & RUPR. =NEEDLEANDTHREAD	
STCOC	STIPA	COMATA	COMATA	TRIN. & RUPR. =NEEDLEANDTHREAD	
STCOI	STIPA	COMATA	INTERMEDIA	SCRIBN. & TWEEDY =TWEEDY NEEDLEGRASS	
STEL	STIPA	ELMERI		PIPER & BRODIE EX SCRIBN. =ELMER NEEDLEGRASS	1
STLE 2	STIPA	LEMMONII		(VASEY) SCRIBN. =LEMMON NEEDLEGRASS	
STLE	STIPA	LETTERMANII		VASEY =LETTERMAN NEEDLEGRASS	
STOC	STIPA	OCCIDENTALIS		THURB. EX WATS. =WESTERN NEEDLEGRASS	
STOCC	STIPA	OCCIDENTALIS	CALIFORNICA	(MERR. & DAVY) C. L. HITCHC. =	
STOCM	STIPA	OCCIDENTALIS	MINOR	(VASEY) C. L. HITCHC. =	
STOCN	STIPA	OCCIDENTALIS	NELSONII	(SCRIBN.) C. L. HITCHC. =	
STPI 2	STIPA	PINETORUM		M. E. JONES =	
STPU	STIPA	PULCHRA		A. S. HITCHC. =PURPLE NEEDLEGRASS	
STRI 2	STIPA	RICHARDSONII		LINK =RICHARDSON NEEDLEGRASS	
STSC 2	STIPA	SCRIBNERI		VASEY =SCRIBNER NEEDLEGRASS	
STSP 2	STIPA	SPARTEA		TRIN. =	
STSPC	STIPA	SPARTEA	CURTISETA	A. S. HITCHC. =	1
STSP	STIPA	SPECIOSA		TRIN. & RUPR. =DESERT NEEDLEGRASS	
STTH	STIPA	THURBERIANA		PIPER =THURBER NEEDLEGRASS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
STVI	STIPA	VIRIDULA		TRIN. =GREEN NEEDLEGRASS	
STWI	STIPA	WILLIAMSII		SCRIBN. =WILLIAMS NEEDLEGRASS	1
TAENI	TAENIATHERUM			NEVSKI =	2
TAAS	TAENIATHERUM	ASPERUM		(SIMONKAI) NEVSKI =	2
TRISE	TRISETUM			PERS. =TRISETUM	
TRCA	TRISETUM	CANESCENS		BUCKL. =TALL TRISETUM	
TRCE	TRISETUM	CERNUUM		TRIN. =NODDING TRISETUM	
TRFL	TRISETUM	FLAVESCENS		(L.) BEAUV =	
TRSP	TRISETUM	SPICATUM		(L.) RICHT. =SPIKE TRISETUM	
TRWO	TRISETUM	WOLFII		VASEY =WOLFS TRISETUM	
TRITI	TRITICUM			L. =WHEAT	
TRAE	TRITICUM	AESTIVUM		L. =WHEAT	
VENTE	VENTENATA			KOELER =VENTENATA	
VEDU	VENTENATA	DUBIA		COSS. & DUR. =	
ZIZAN	ZIZANIA			L. =INDIAN RICE; WILD RICE	
ZIAQ	ZIZANIA	AQUATICA		L. =	



Grasslike Plants

Sedges and rushes

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SYN. CODE
BULBO	BULBOSTYLIS			DC.	=BULBOSTYLIS	
BUCA	BULBOSTYLIS	CAPILLARIS		(L.) C. B. CLARKE	=	
CAREX	CAREX			L.	=SEDGE	
CAAB	CAREX	ABLATA		L. H. BAILEY	=WINGSEED SEDGE	1
CAAB 3	CAREX	ABORIGINUM		M. E. JONES	=	
CAAB 2	CAREX	ABRUPTA		MACKENZIE	=ABRUPTBEAK SEDGE	
CAAE	CAREX	AENEA		FERN.	=	
CAAL	CAREX	ALBONIGRA		MACKENZIE IN RYDB.	=	
CAAM	CAREX	AMPLIFOLIA		BOOTT	=BIGLEAF SEDGE	
CAAP 3	CAREX	AFERTA		BOOTT	=	
CAAQ	CAREX	AQUATILIS		WAHL.	=WATER SEDGE	
CAAR 2	CAREX	ARCTA		BOOTT	=	
CAAT 2	CAREX	ATHERODES		SPRENG.	=	
CAAT	CAREX	ATHROSTACHYA		OLNEY	=SLENDERBEAK SEDGE	
CAAT 3	CAREX	ATRATA		L.	=	
CAATA	CAREX	ATRATA	ATROSQUAMA	(MACKENZIE) CRONQ.	=	
CAATC	CAREX	ATRATA	CHALCIOLEPIS	(HOLM) KUEKENTH.	=	
CAATE	CAREX	ATRATA	ERECTA	W. BOOTT	=	
CAAU	CAREX	AUREA		NUTT.	=GOLDEN SEDGE	
CABA	CAREX	BACKII		BOOTT	=	
CABE	CAREX	BEBBII		OLNEY EX FERN.	=	
CABO	CAREX	BOLANDERI		OLNEY	=BOLANDER SEDGE	1
CABR 4	CAREX	BREVICAULIS		MACK.	=	
CABR 5	CAREX	BREVIOR		(DEWEY) MACKENZIE EX LUNELL	=	
CABR	CAREX	BREWERI		BOOTT	=BREWER SEDGE	
CABRP	CAREX	BREWERI	PADDOENSIS	(SUKSD.) CRONQ.	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
CABR 6	CAREX	BRUNNESCENS		(PERS.) POIR.	=	
CABU 3	CAREX	BUXBAUMII		WAHL.	=BUXBAUM SEDGE	
CACA 2	CAREX	CALIFORNICA		L. H. BAILEY	=CALIFORNIA SEDGE	
CACA 3	CAREX	CAMPYLOCARPA		HOLM.	=CRATER LAKE SEDGE	1
CACA 4	CAREX	CANESCENS		L.	=	
CACI 2	CAREX	CIRCINATA		C. A. MEY.	=	
CACO 3	CAREX	CONCINNA		R. BR.	=	
CACO	CAREX	CONCINNOIDES		MACK.	=NORTHWESTERN SEDGE	
CACR 3	CAREX	CRAWFORDII		FERN.	=	
CACU 2	CAREX	CUSICKII		MACK.	=CUSICK SEDGE	
CADE 2	CAREX	DENSA		(L. H. BAILEY) L. H. BAILEY	=	
CADE	CAREX	DEWEYANA		SCHW.	=DEWEY SEDGE	
CADI 2	CAREX	DIANDRA		SCHRANK	=	
CADIG	CAREX	DIOICA	GYNOCRATES	L.	=YELLOW BOG SEDGE	
CADI	CAREX	DISPERMA		DEWEY	=	
CADO	CAREX	DOUGLASII		BOOTT	=DOUGLAS SEDGE	
CADR	CAREX	DRUMMONDIANA		DEWEY	=	1
CAEP	CAREX	EPAPILLOSA		MACK.	=	1
CAEU	CAREX	EURYCARPA		HOLM.	=WIDEFRUIT SEDGE	
CAEX	CAREX	EXSICCATA		L. H. BAILEY	=COLUMBIA SEDGE	1
CAFE	CAREX	FESTIVELLA		MACK.	=OVALHEAD SEDGE	1
CAFE 2	CAREX	FETA		L. H. BAILEY	=	
CAFI	CAREX	FILIFOLIA		NUTT.	=THREADLEAF SEDGE	
CAFL	CAREX	FLAVA		L.	=	
CAFOT	CAREX	FOENEA	TUBERCULATA	F. J. HERM.	=	1
CAFO	CAREX	FOETIDA		ALLIONI	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
CAFR	CAREX	FFACTA		MACKENZIE	=	
CAGE	CAREX	GEYERI		BOOTT	=ELK SEDGE	
CAGY	CAREX	GYMNOCLADA		HOLM.	=	1
CAHA 2	CAREX	HALLIANA		L. H. BAILEY	=	
CAHA	CAREX	HAYDENIANA		OLNEY	=HAYDEN SEDGE	
CAHE	CAREX	HENDERSONI		L. H. BAILEY	=	
CAHO	CAREX	HOODII		BOOTT	=HOOD SEDGE	
CAIL	CAREX	ILLOTA		L. H. BAILEY	=SHEEP SEDGE	
CAIN 4	CAREX	INOPS		L. H. BAILEY	=	1
CAIN 2	CAREX	INTEGRA		MACKENZIE	=	
CAIN 5	CAREX	INTERIOR		L. H. BAILEY	=INLAND SEDGE	
CAIN 3	CAREX	INTERRUPTA		BOECK.	=	
CAJO	CAREX	JONESII		L. H. BAILEY	=	
CAKE	CAREX	KELLOGGII		BOOTT	=KELLOGG SEDGE	1
CALA	CAREX	LAEVICULMIS		MEINSH.	=	
CALA 3	CAREX	LANUGINOSA		MICHX.	=WOOLLY SEDGE	
CALA 4	CAREX	LASIOCARPA		EHRH.	=	
CALE 5	CAREX	LENTICULARIS		MICHX.	=	
CALEL	CAREX	LENTICULARIS	LIMNOPHILA	(HOLM) CRONQ.	=	
CALE 6	CAREX	LEPORINA		L.	=	
CALE 3	CAREX	LEPORINELLA		MACK.	=	
CALE 4	CAREX	LEPTOPODA		MACK.	=	1
CALI 3	CAREX	LIMNOPHILA		HERMANN	=	
CALI	CAREX	LIMOSA		L.	=MUD SEDGE	
CALI 4	CAREX	LIVIDA		(WAHL.)	=	
CALU	CAREX	LUZULINA		OLNEY	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
CALY 3	CAREX	LYNGBYEI		HORNEM. =	
CAMA 2	CAREX	MACROCEPHALA		WILLD. EX SPRENG. =	
CAMA 4	CAREX	MACROCHAETA		C. A. MEY. =	
CAME 2	CAREX	MERTENSII		PRESCOTT EX BONG. =MERTENS SEDGE	
CAMI	CAREX	MICROPTERA		MACK. =SMALLWING SEDGE	
CAMU	CAREX	MULTICOSTATA		MACK. =	
CAMU 2	CAREX	MURICATA		L. =	
CANA 2	CAREX	NARDINA		FRIES =	
CANE	CAREX	NEBRASKENSIS		DEWEY =NEBRASKA SEDGE	
CANE 2	CAREX	NEUROPHORA		MACK. =	
CANI 2	CAREX	NIGRICANS		C. A. MEY. =BLACK ALPINE SEDGE	
CANO	CAREX	NOVA		L. H. BAILEY =	
CANU	CAREX	NUBICOLA		MACK. =CLOUD SEDGE	1
CANU 4	CAREX	NUDATA		BOOTT =	
CAOB	CAREX	OBNUPTA		L. H. BAILEY =	
CAOB 2	CAREX	OBOVOIDEA		CRONQ. =	
CAOE	CAREX	OEDERI		RETZ. =	
CAOR	CAREX	OREGONENSIS		OLNEY EX L. H. BAILEY =OREGON SEDGE	1
CAPA 2	CAREX	PACHYCARPA		MACK. =	1
CAPA	CAREX	PACHYSTACHYA		CHAM. =CHAMISSO SEDGE	
CAPA 4	CAREX	PANSA		L. H. BAILEY =	
CAPA 7	CAREX	PARRYANA		DEWEY =	
CAPA 9	CAREX	PAUPERCULA		MICHX. =	
CAPE 5	CAREX	PENSYLVANICA		LAM. =	
CAPED	CAREX	PENSYLVANICA	DIGYNA	BOECK. =	
CAPEV	CAREX	PENSYLVANICA	VESPERTINA	L. H. BAILEY =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
CAPE	CAREX	PETASATA		DEWEY	=LIDDON SEDGE	
CAPH	CAREX	PHAEOCEPHALA		PIPER	=DUNHEAD SEDGE	
CAPH 2	CAREX	PHYLLOMANICA		W. BOOTT	=	
CAPL	CAREX	PLURIFLORA		HULTEN	=	
CAPR 7	CAREX	PRAECEPTORUM		MACKENZIE	=	
CAPR 5	CAREX	PRAEGRACILIS		BOOTT	=CLUSTERED FIELD SEDGE	
CAPR 6	CAREX	PRAIREA		DEWEY	=PRAIRIE SEDGE	
CAPR	CAREX	PRATICOLA		RYDB.	=	
CAPR 2	CAREX	PRESLII		STEUD.	=PRESL SEDGE	1
CAPR 8	CAREX	PRIONOPHYLLA		HOLM.	=	
CAPR 9	CAREX	PROPOSITA		MACKENZIE	=	
CAPY	CAREX	PYRENAICA		WAHL.	=	
CARA	CAREX	RAYNOLDSII		DEWEY	=RAYNOLDS SEDGE	
CARE	CAREX	RETRORSA		SCHW.	=	
CARO	CAREX	ROSSII		BOOTT	=ROSS SEDGE	
CARO 2	CAREX	ROSTRATA		STOKES EX WITH.	=BEAKED SEDGE	
CARU 2	CAREX	RUPESTRIS		ALLIONI	=	
CASA 2	CAREX	SAXATILIS		L.	=	
CASA	CAREX	SAXIMONTANA		MACK.	=ROCKY MOUNTAIN SEDGE	1
CASC 3	CAREX	SCIRPOIDEA		MICHX.	=	
CASCP	CAREX	SCIRPOIDEA	PSEUDOSCIRPOIDEA	(RYDB.) CRONQ.	=	
CASCS	CAREX	SCIRPOIDEA	SCIRPOIDEA	MICHX.	=	
CASCS2	CAREX	SCIRPOIDEA	STENOCHLAENA	HOLM	=	
CASC 4	CAREX	SCOPARIA		SCHK. EX WILLD.	=	
CASC 5	CAREX	SCOPULORUM		HOLM	=	
CASH	CAREX	SHELDONII		MACKENZIE	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME ALTHORSHIP COMMON NAME	S C
CASI	CAREX	SICCATA		DEWEY =SILVERTOP SEDGE	
CASI 2	CAREX	SIMULATA		MACK. =ANALOGUE SEDGE	
CASI 3	CAREX	SITCHENSIS		PRESCOTT =SITKA SEDGE	
CASP	CAREX	SFECTABILIS		DEWEY =	
CASP 2	CAREX	SPRENGELII		DEWEY EX SPRENG. =	
CAST 4	CAREX	STENJPHYLLA		WAHL. =	
CAST	CAREX	STIPATA		MUHL. =SAWBEAK SEDGE	
CAST 2	CAREX	STRAMINIFORMIS		L. H. BAILEY =	
CAST 3	CAREX	STYLOSA		C. A. MEY. =	
CASU 4	CAREX	SLBFUSCA		BOOTT =	
CASU 5	CAREX	SLBNIGRICANS		STACEY =	
CASU 2	CAREX	SUBSTRICTA		MACK. =	1
CASY	CAREX	SYCHNOCEPHALA		CAREY =	
CATE	CAREX	TENERAEFORMIS		MACK. =SIERRA SLIM SAGE	1
CATO 2	CAREX	TOLMIEI		BOOTT =TOLMIE SEDGE	
CATR 2	CAREX	TRACYI		MACK. =TRACY SEDGE	1
CATU	CAREX	TUMULICOLA		MACKENZIE =	
CAUN 2	CAREX	UNILATERALIS		MACKENZIE =	
CAVA	CAREX	VALLICOLA		DEWEY =	
CAVE	CAREX	VESICARIA		L. =BLISTER SEDGE	
CAVI	CAREX	VIRIJIOR		MACK. =	
CAVU	CAREX	VULPINOIDEA		MICHX. =	
CYPER	CYPERUS			L. =FLATSEDGE	
CYAR	CYPERUS	ARISTATUS		ROTTB. =	
CYER	CYPERUS	ERAGROSTIS		LAM. =	
CYIN	CYPERUS	INFLEXUS		MUHL. =AWNED CYPERUS	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
CYSC 2	CYPERUS	SCHWEINITZII		TORR. =	
CYST	CYPERUS	STRIGOSUS		L. =	
DULIC	DULICHIUM			PERS. =DULICHIUM	
DUAR	DULICHIUM	ARUNDINACEUM		(L.) BRITT. =	
ELEOC	ELEOCHARIS			R. BR. =SPIKE-RUSH	
ELAC	ELEOCHARIS	ACICULARIS		(L.) =	
ELAT	ELEOCHARIS	ATROPURPUREA		(RETZ.) KUNTH =	
ELBE	ELEOCHARIS	BELLA		(PIPER) SVENSON =	
ELBO	ELEOCHARIS	BOLANDERI		GRAY =	
ELMA	ELEOCHARIS	MACROSTACHYA		BRITT. EX SMALL =LONGSTEM SPIKE-RUSH	1
ELOV	ELEOCHARIS	OVATA		(ROTH) R. & S. =	
ELPA	ELEOCHARIS	PALUSTRIS		(L.) R. & S. =COMMON SPIKE-RUSH	
ELPA 3	ELEOCHARIS	PARVULA		(R. & S.) LINK EX BLUFF & FINGERH. =	
ELPA 2	ELEOCHARIS	PAUCIFLORA		(LIGHTF.) LINK =FEWFLOWERED SPIKE-RUSH	
ELRO	ELEOCHARIS	ROSTELLATA		(TORR.) TORR. =	
ERIOP	ERIOPHORUM			L. =COTTONSEDGE	
ERCH 2	ERIOPHORUM	CHAMISSONIS		C. A. MEY. =CHAMISSO COTTONSEDGE	
ERGR 2	ERIOPHORUM	GRACILE		KOCK =SLENDER COTTONSEDGE	
ERPO 2	ERIOPHORUM	POLYSTACHION		L. =	
ERVI 2	ERIOPHORUM	VIRIDICARINATUM		(ENGELM.) FERN. =	
HEMIC	HEMICARPHA			NEES =HEMICARPHA	
HEMI 3	HEMICARPHA	MICRANTHA		(VAHL) BRITT. =	
HEOC 2	HEMICARPHA	OCCIDENTALIS		GRAY =	
JUNCU	JUNCUS			L. =RUSH	
JUAC	JUNCUS	ACUMINATUS		MICHX. =	
JUAL	JUNCUS	ALPINUS		VILL. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
JUAR	JUNCUS	ARTICULATUS		L. =	
JUBA 2	JUNCUS	BADIUS		SUKSD. =	1
JUBA	JUNCUS	BALTICUS		WILLD. =BALTIC RUSH	
JUBAB	JUNCUS	BALTICUS	BALTICUS	WILLD. =BALTIC RUSH	
JUBAM	JUNCUS	BALTICUS	MONTANUS	ENGELM. =	
JUBO	JUNCUS	BOLANDERI		ENGELM. =BOLANDER RUSH	
JUBR	JUNCUS	BRACHYPHYLLUS		WIEG. =	
JUBU	JUNCUS	BUFONIUS		L. =TOAD RUSH	
JUCO 3	JUNCUS	COLUMBIANUS		COV. =COLUMBIAN RUSH	
JUCO	JUNCUS	CONFUSUS		COV. =COLORADO RUSH	
JUCO 2	JUNCUS	COVILLEI		PIPER =COVILLE RUSH	
JUCOO	JUNCUS	COVILLEI	OBTUSATUS	C. L. HITCHC. =	
JUDR	JUNCUS	DRUMMONDII		E. MEY. =DRUMMOND RUSH	
JUDRS	JUNCUS	DRUMMONDII	SUBTRIFLORUS	(E. MEYER) C. L. HITCHC. =	
JUDU	JUNCUS	DUDLEYI		WIEG. =DUDLEY RUSH	1
JUEF	JUNCUS	EFFUSUS		L. =COMMON RUSH	
JUEFB	JUNCUS	EFFUSUS	BRUNNEUS	ENGELM. =	1
JUEFE	JUNCUS	EFFUSUS	EFFUSUS	L. =COMMON RUSH	
JUEFG	JUNCUS	EFFUSUS	GRACILIS	HOOK. =	
JUEN	JUNCUS	ENSIFOLIUS		WILSK. =SWORDLEAF RUSH	
JUENM	JUNCUS	ENSIFOLIUS	MONTANUS	(ENGELM.) C. L. HITCHC. =	
JUFA	JUNCUS	FALCATUS		E. MEYER =	
JUFAS	JUNCUS	FALCATUS	SITCHENSIS	BUCH. =	
JUFI	JUNCUS	FILIFORMIS		L. =	
JUFU	JUNCUS	FUCENSIS		ST. JOHN =	
JUGE	JUNCUS	GERARDII		LOISEL. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
JUHE	JUNCUS	HEMIENDYTUS		F. J. HERMANN =	
JUHO	JUNCUS	HOWELLII		F. J. HERM. =	
JUKE	JUNCUS	KELLOGGII		ENGELM. =	
JULE	JUNCUS	LESEURII		BOLAND. =PACIFIC RUSH	
JULO	JUNCUS	LONGISTYLIS		TORR. =	
JUME	JUNCUS	MERTENSIANUS		BONG. =MERTENS' RUSH	
JUMES	JUNCUS	MERTENSIANUS	SUKSDORFII	F. J. HERM. =	1
JUNE	JUNCUS	NEVADENSIS		WATS. =NEVADA RUSH	
JUNEB	JUNCUS	NEVADENSIS	BADIUS	(SUKSD.) C. L. HITCHC. =	
JUNEI	JUNCUS	NEVADENSIS	INVENTUS	(HENDERSON) C. L. HITCHC. =	
JUNO	JUNCUS	NODOSUS		L. =JOINTED RUSH	
JUOC 2	JUNCUS	OCCIDENTALIS		WIEG. =WESTERN RUSH	1
JUOR 2	JUNCUS	OREGANUS		WATS. =	1
JUOR	JUNCUS	ORTHOPHYLLUS		COV. =	
JUOX	JUNCUS	OXYMERIS		ENGELM. =	
JUPA	JUNCUS	PARRYI		ENGELM. =PARRY RUSH	
JUPA 2	JUNCUS	PATENS		E. MEYER =	
JURE	JUNCUS	REGELII		BUCH. =REGEL RUSH	
JUSA	JUNCUS	SAXIMONTANUS		A. NELS. =ROCKY MOUNTAIN RUSH	1
JUSU	JUNCUS	SUPINIFORMIS		ENGELM. =	
JUSU 2	JUNCUS	SUPINUS		MOENCH =	
JUTE	JUNCUS	TENUIS		WILLD. =	
JUTEC	JUNCUS	TENUIS	CONGESTUS	ENGELM. =	
JUTED	JUNCUS	TENUIS	DUDLEYI	(WIEG.) F. J. HERMANN =	
JUTET	JUNCUS	TENUIS	TENUIS	WILLD. =	
JUTO	JUNCUS	TORREYI		COV. =TORREY RUSH	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
JUVA	JUNCUS	VASEYI		ENGELM. =	
KOBRE	KOBRESIA			WILLD. =KOBRESIA	
KOSI	KOBRESIA	SIMPLICIUSCULA		(WAHL.) MACKENZIE =	
LILAE	LILAEA			HUMB. & BONPL. =FLOWERING QUILLWORT	
LISC	LILAEA	SCILLOIDES		(POIR.) HAUMAN =	
LUZUL	LUZULA			DC. =WOODRUSH	
LUAR 4	LUZULA	ARCUATA		(WAHLENB.) WAHLENB. =	
LUCA 2	LUZULA	CAMPESTRIS		(L.) DC. =FIELD WOODRUSH	
LUCAM	LUZULA	CAMPESTRIS	MULTIFLORA	(EHRH.) CELAK. =	
LUCO	LUZULA	COMOSA		E. MEY. =HAIRY WOODRUSH	1
LUDI	LUZULA	DIVARICATA		WATS. =	
LUGL	LUZULA	GLABRATA		(HOPPE) DESV. =	
LUMU	LUZULA	MULTIFLORA		LEJEUNE =	1
LUMUC2	LUZULA	MULTIFLORA	COMOSA	ST.JOHN. =	1
LUPA	LUZULA	PARVIFLORA		(EHRH.) DESV. =MILLET WOODRUSH	
LUPI	LUZULA	PIPERI		(COV.) M. E. JONES =	1
LUSP	LUZULA	SPICATA		(L.) DC. =SPIKE WOODRUSH	
LUSU 4	LUZULA	SUBSESSILIS		BUCH. =	1
LUWA	LUZULA	WAHLENBERGII		RUPR. =WAHLENBERG WOODRUSH	
NAJAS	NAJAS			L. =WATER-NYMPH	
NAFL	NAJAS	FLEXILIS		(WILLD.) ROST. & SCHMIDT =	
NAGU	NAJAS	GUADALUPENSIS		(SPRENG.) MORONG =	
PHYLL2	PHYLLOSPADIX			HOOK. =SURF-GRASS	
PHSC	PHYLLOSPADIX	SCOULERI		HOOK. =	
RHYNC	RHYNCHOSPORA			VAHL =BEAKRUSH	
RHAL 3	RHYNCHOSPORA	ALBUS		(L.) VAHL =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
RUPPI	RUPPIA			L. =DITCH-GRASS	
RUMA 3	RUPPIA	MARITIMA		L. =	
RUOC 3	RUPPIA	OCCIDENTALIS		WATS. =	
SCIRP	SCIRPUS			L. =BULRUSH	
SCAC	SCIRPUS	ACUTUS		MUHL. EX BIGEL. =	
SCAM	SCIRPUS	AMERICANUS		PERS. =AMERICAN BULRUSH	
SCAT	SCIRPUS	ATROVIRENS		WILLD. =GREEN BULRUSH	
SCCE	SCIRPUS	CERNUUS		VAHL =	
SCCE 2	SCIRPUS	CESPITOSUS		L. =	
SCCO	SCIRPUS	CONGDONII		BRITT. =	
SCHE	SCIRPUS	HETEROCHAETUS		CHASE =PALE BULRUSH	2
SCMA	SCIRPUS	MARITIMUS		L. =	
SCMI	SCIRPUS	MICROCARPUS		PRESL. =PANICLED BULRUSH	
SCNE	SCIRPUS	NEVADENSIS		WATS. =	
SCOL	SCIRPUS	OLNEYI		GRAY =OLNEY BULRUSH	
SCPA 3	SCIRPUS	PALLIDUS		(BRITT.) FERN. =	
SCPA	SCIRPUS	PAUCIFLORUS		LIGHTF. =	2
SCSU	SCIRPUS	SUBTERMINALIS		TORR. =	
SCVA	SCIRPUS	VALIDUS		VAHL. =SOFTSTEM BULRUSH	
TRIGL	TRIGLOCHIN			L. =PODGRASS	
TRCO	TRIGLOCHIN	CONCINNUM		DAVY =	
TRCOD	TRIGLOCHIN	CONCINNUM	DEBILE	(M. E. JONES) J. T. HOWELL =	
TRMA 2	TRIGLOCHIN	MARITIMUM		L. =SHORE PODGRASS	
TRPA	TRIGLOCHIN	PALUSTRE		L. =	
VALLI	VALLISNERIA			L. =TAPEGRASS; WILD CELERY	
VAAM	VALLISNERIA	AMERICANA		MICHX. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ZANNI	ZANNICHELLIA			L. =HORNED PONDWEED	
ZAPA	ZANNICHELLIA	PALUSTRIS		L. =	
ZOSTE	ZOSTERA			L. =EEL-GRASS	
ZOMA	ZOSTERA	MARINA		L. =	
ZONA	ZOSTERA	NANA		ROTH =	

Forbs

Broad-leaved flowering herbs,
plus ferns and allied families

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SYN. CODE
ABRON	ABRONIA			JUSS. =SANDVERBENA	
ABFR	ABRONIA	FRAGRANS		NUTT. EX HOOK. =	
ABLA	ABRONIA	LATIFOLIA		ESCHSCH. =YELLOW SANDVERBENA	
ABME	ABRONIA	MELLIFERA		DOUGL. EX HOOK. =WHITE ABRONIA	
ABUM	ABRONIA	UMBELLATA		LAM. =PINK SANDVERBENA	
ABUMA	ABRONIA	UMBELLATA	ACUTALATA	(STANDL.) HITCHC. =	
ABUMU	ABRONIA	UMBELLATA	UMBELLATA	LAM. =	
ACHIL	ACHILLEA			L. =YARROW	
ACLA	ACHILLEA	LANULOSA		NUTT. =	1
ACMI	ACHILLEA	MILLEFOLIUM		L. =	
ACMIL	ACHILLEA	MILLEFOLIUM	LANULOSA	PIPER =WESTERN YARROW	1
ACHLY	ACHLYS			DC. =VANILLALEAF	
ACTR	ACHLYS	TRIPHYLLA		(SMITH) DC. =DEERFOOT VANILLALEAF	
ACHYR	ACHYRACHAENA			SCHAUER. =BLOWWIVE	
ACMO	ACHYRACHAENA	MOLLIS		SCHAUER. =BLOWWIVES	
ACDE	ACOMASTYLIS	DEPRESSA		GREENE =	2
ACONI	ACONITUM			L. =MONKSHOOD	
ACCO	ACONITUM	COLUMBIANUM		NUTT. =COLUMBIA MONKSHOOD	
ACCOH	ACONITUM	COLUMBIANUM	HOWELLII	(NELS. & MACBR.) C. L. HITCHC. =	
ACGR	ACONITUM	GRACILENTUM		GREENE =	
ACHE	ACONITUM	HELLERI		GREENE =HELLER MONKSHOOD	
ACHO	ACONITUM	HOWELLII		NELS. & MACBR. =	1
ACORU	ACORUS			L. =SWEETFLAG	
ACCA	ACORUS	CALAMUS		L. =	
ACTAE	ACTAEA			L. =BANEBERRY	
ACAR	ACTAEA	ARGUTA		NUTT. EX T. & G. =	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ACRU	ACTAEA	RUBRA		(AIT.) WILLD. =	
ACRUA	ACTAEA	RUBRA	ARGUTA	(NUTT.) HULT. =	
ADENO	ADENOCAULON			HOOK. =ADENOCAULON; TRAIL PLANT; PATHFINDER	
ADBI	ADENOCAULON	BICOLOR		HOOK. =AMERICAN ADENOCAULON	
ADIAN	ADIANTUM			L. =MAIDENHAIR FERN	
ADCA	ADIANTUM	CAPILLUS-VENERIS		L. =	
ADPE	ADIANTUM	PEDATUM		L. =	
ADPEA	ADIANTUM	PEDATUM	ALEUTICUM	RUPR. =	1
AGAST	AGASTACHE			KTZE =GIANTHYSSOP; HORSE-MINT	
AGCU	AGASTACHE	CUSICKII		(GREENM.) HELLER =	
AGFO	AGASTACHE	FOENICULUM		KTZE. =FENNEL GIANTHYSSOP	
AGOC	AGASTACHE	OCCIDENTALIS		HELLER =	
AGUR	AGASTACHE	URTICIFOLIA		KTZE. =NETTLELEAF GIANTHYSSOP	
AGOSE	AGOSERIS			RAF. =AGOSERIS	
AGAL 2	AGOSERIS	ALPESTRIS		GREENE =	2
AGAP	AGOSERIS	APARGIOIDES		GREENE =SEASIDE AGOSERIS	
AGAU	AGOSERIS	AURANTIACA		GREENE =ORANGE AGOSERIS	
AGEL 2	AGOSERIS	ELATA		GREENE =TALL AGOSERIS	
AGGL	AGOSERIS	GLAUCA		(PURSH) RAF. =PALE AGOSERIS	
AGGLA	AGOSERIS	GLAUCA	AGRESTIS	(OSTERH.) JONES EX CRONQ. =	
AGGLD	AGOSERIS	GLAUCA	DASYCEPHALA	(T. & G.) JEPS. =	
AGGLG	AGOSERIS	GLAUCA	GLAUCA	(PURSH)RAF. =PALE AGOSERIS	
AGGLL	AGOSERIS	GLAUCA	LACINIATA	(D. C. EAT.) SMILEY =	
AGGLM	AGOSERIS	GLAUCA	MONTICOLA	(GREENE) Q. JONES =	
AGGR 2	AGOSERIS	GRACILENS		KTZE. =BIGFLOWER AGOSERIS	1
AGGR	AGOSERIS	GRANDIFLORA		(NUTT.) GREENE =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
AGHE	AGOSERIS	HETEROPHYLLA		JEPSON =ANNUAL AGOSERIS	
AGLA	AGOSERIS	LACINIATA		GREENE =	1
AGRE 2	AGOSERIS	RETRORSA		GREENE =	
AGSCA	AGOSERIS	SCORZONERAEFOLIA	ASPERA	BLAKE =	1
AGTA	AGOSERIS	TARAXACIFOLIA		D. DIETR. =DANDELION AGOSERIS	1
AGTE 2	AGOSERIS	TENUIFOLIA		RYDB. =	
AGROS2	AGROSTEMMA			L. =CORNCOCKLE	
AGGI	AGROSTEMMA	GITHAGO		L. =COMMON CORNCOCKLE	
AJRE	AJUGA	REPTANS		L. =	
ALISM	ALISMA			L. =WATERPLANTAIN	
ALGE 3	ALISMA	GEYERI		TORR. EX NICOLETT =	1
ALGR	ALISMA	GRAMINEUM		GMEL. =	
ALGRA	ALISMA	GRAMINEUM	ANGUSTISSIMUM	(DC.) HENDRICKS =	
ALGRG	ALISMA	GRAMINEUM	GRAMINEUM	GMEL. =	
ALPLG	ALISMA	PLANTAGO	GRAMINIFOLIA	WAHLENB. =	
ALPL 3	ALISMA	PLANTAGO-AQUATICA		L. =AMERICAN WATERPLANTAIN	
ALLIU	ALLIUM			L. =ONION	
ALAA	ALLIUM	AASEAE		OWNBEY =	
ALAC	ALLIUM	ACUMINATUM		HOOK. =TAPERTIP ONION	
ALAM	ALLIUM	AMPLECTENS		TORR. =SLIMLEAF ONION	
ALANA	ALLIUM	ANCEPS	ABERRANS	M. E. JONES =	1
ALBI	ALLIUM	BISCEPTRUM		WATS. =	1
ALBR	ALLIUM	BRANDEGEI		WATS. =BRANDEGEE ONION	
ALBR 2	ALLIUM	BREVISTYLUM		WATS. =	
ALCA	ALLIUM	CAMPANULATUM		WATS. =SIERRA ONION	
ALCE	ALLIUM	CERNUUM		ROTH =NODDING ONION	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ALCR	ALLIUM	CRENULATUM		WIEG. =	
ALCU	ALLIUM	CUSICKII		WATS. =CUSICK ONION	1
ALDI	ALLIUM	DICTUON		ST. JOHN =	
ALDO	ALLIUM	DOUGLASII		HOOK. =DOUGLAS ONION	
ALDOC	ALLIUM	DOUGLASII	COLUMBIANUM	OWNBEY & MINGRONE =	
ALDOC2	ALLIUM	DOUGLASII	CONSTRICTUM	MINGRONE & OWNBEY =	
ALDON	ALLIUM	DOUGLASII	NEVII	(WATS.) OWNBEY & MINGRONE =	
ALFA	ALLIUM	FALCIFOLIUM		H. & A. =SICKLELEAF ONION	
ALFI	ALLIUM	FIBRILLUM		M. E. JONES EX ABRAMS =BLUEMOUNTAINS ONION	
ALGE 2	ALLIUM	GEYERI		WATS. =GEYER ONION	
ALLE	ALLIUM	LEMMONII		WATS. =	
ALMA	ALLIUM	MACRUM		WATS. =	
ALMA 2	ALLIUM	MADIDUM		WATS. =	
ALNE 2	ALLIUM	NEVADENSE		WATS. =	
ALNE	ALLIUM	NEVII		WATS. =NEVINS ONION	1
ALNI	ALLIUM	NIGRUM		L. =	
ALPA	ALLIUM	PALMERI		WATS. =PALMER ONION	
ALPA 2	ALLIUM	PARVUM		KELL. =	
ALPL	ALLIUM	PLATYCAULE		WATS =FLATSTEM ONION	
ALPL 2	ALLIUM	PLEIANTHUM		WATS. =	
ALRO	ALLIUM	ROBINSONII		HENDERSON =	
ALSC	ALLIUM	SCHOENOPRASUM		L. =	
ALSC 2	ALLIUM	SCILLOIDES		DOUGL. EX WATS. =	
ALSE	ALLIUM	SERRATUM		WATS. =SERRATE ONION	
ALSI 2	ALLIUM	SIMILLIMUM		HENDERSON =	
ALTE 2	ALLIUM	TEXTILE		NELS. & MACBR. =TEXTILE ONION	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ALTO	ALLIUM	TOLMIEI		BAKER EX WATS. =TOLMIE ONION	
ALTOP2	ALLIUM	TOLMIEI	PERSIMILE	OWNBEY =	
ALTOP	ALLIUM	TOLMIEI	PLATYPHYLLUM	OWNBEY =	
ALTOT	ALLIUM	TOLMIEI	TOLMIEI	BAKER EX WATS. =	
ALUN	ALLIUM	UNIFOLIUM		KELL. =	
ALVA	ALLIUM	VALIDUM		WATS. =PACIFIC ONION	
ALLOT	ALLOTROPA			GRAY =CANDYSTICK, SUGARSTICK	
ALVI	ALLOTROPA	VIRGATA		T. & G. EX GRAY =CANDYSTICK	
ALSI 3	ALSINE	SIMCOEI		HOWELL =	2
ALRO 2	ALTHAEA	ROSEA		GRAY =	
ALYSS	ALYSSUM			L. =ALYSSUM	
ALAL	ALYSSUM	ALYSSOIDES		L. =PALE ALYSSUM	
ALDE	ALYSSUM	DESERTORUM		STAPF. =	
AMARA	AMARANTHUS			ADANS. =AMARANTH; PIGWEED	
AMAL 2	AMARANTHUS	ALBUS		L. =	
AMCA	AMARANTHUS	CALIFORNICUS		(MOQ.) WATS. =	
AMGR	AMARANTHUS	GRAECIZANS		L. =	
AMHY	AMARANTHUS	HYBRIDUS		L. =SLIM AMARANTH	
AMRE	AMARANTHUS	RETROFLEXUS		L. =REDROOT AMARANTH	
AMBRO	AMBROSIA			L. =RAGWEED	
AMAC	AMBROSIA	ACANTHICARPA		HOOK. =	
AMAR 2	AMBROSIA	ARTEMISIFOLIA		L. =COMMON RAGWEED	
AMCH	AMBROSIA	CHAMISSONIS		GREENE =	
AMMAN	AMMANNIA			L. =AMMANNIA	
AMCO	AMMANNIA	COCCINEA		ROTTB. =	
AMORP	AMORPHA			L. =AMORPHA	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
AMSIN	AMSINCKIA			LEHM. =FIDDLENECK	
AMIN	AMSINCKIA	INTERMEDIA		FISCH. & MEY. =FIREWEED FIDDLENECK	
AMLY	AMSINCKIA	LYCOPSIOIDES		LEHM. EX FISCH. & MEY. =TARWEED FIDDLENECK	
AMME	AMSINCKIA	MENZIESII		(LEHM.) NELS. & MACBR. =MENZIES FIDDLENECK	
AMRE 2	AMSINCKIA	RETRORSA		SUKSD. =RIGID FIDDLENECK	
AMSP	AMSINCKIA	SPECTABILIS		FISCH. & MEY. =	
AMTE	AMSINCKIA	TESSELLATA		GRAY =TESELLATE FIDDLENEC	
ANAGA	ANAGALLIS			L. =PIMPERNEL	
ANAR 3	ANAGALLIS	ARVENSIS		L. =SCARLET PIMPERNEL	
ANAPH	ANAPHALIS			DC. =PEARLEVERLASTING	
ANMA	ANAPHALIS	MARGARITACEA		(L.) B. & H. =COMMON PEARLEVERLASTING	
ANMAM	ANAPHALIS	MARGARITACEA	MARGARITACEA	(L.)B. & H. =COMMON PEARLEVERLASTING	
ANMAO	ANAPHALIS	MARGARITACEA	OCCIDENTALIS	GREENE =WESTERN COMMON PEARLEVERLASTING	
ANMAS	ANAPHALIS	MARGARITACEA	SUBALPINA	GRAY =WESTERN COMMON PEARLEVERLASTING	
ANCHU	ANCHUSA			L. =BUGLOSS	
ANAZ	ANCHUSA	AZUREA		MILL. =ITALIAN BUGLOSS	
ANOF	ANCHUSA	OFFICINALIS		L. =COMMON BUGLOSS	
ANDRO	ANDROSACE			L. =ROCKJASMINE	
ANFI	ANDROSACE	FILIFORMIS		RETZ. =	
ANLE	ANDROSACE	LEHMANNIANA		SPRENG. =	
ANSE	ANDROSACE	SEPTENTRIONALIS		L. =	
ANEMO	ANEMONE			L. =ANEMONE; WINDFLOWER	
ANDE	ANEMONE	DELTOIDEA		HOOK. =THREELEAF ANEMONE	
ANDR	ANEMONE	DRUMMONDII		WATS. =DRUMMOND ANEMONE	
ANGL	ANEMONE	GLOBOSA		NUTT. EX PRITZ. =PACIFIC ANEMONE	1
ANHU	ANEMONE	HUDSONIANA		RICHARDS. =HUDSONIAN ANEMONE	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
ALTO	ALLIUM	TOLMIEI		BAKER EX WATS. =TOLMIE ONION	
ALTOP2	ALLIUM	TOLMIEI	PERSIMILE	OWNBEY =	
ALTOP	ALLIUM	TOLMIEI	PLATYPHYLLUM	OWNBEY =	
ALTOT	ALLIUM	TOLMIEI	TOLMIEI	BAKER EX WATS. =	
ALUN	ALLIUM	UNIFOLIUM		KELL. =	
ALVA	ALLIUM	VALIDUM		WATS. =PACIFIC ONION	
ALLOT	ALLOTROPA			GRAY =CANDYSTICK, SUGARSTICK	
ALVI	ALLOTROPA	VIRGATA		T. & G. EX GRAY =CANDYSTICK	
ALSI 3	ALSINE	SIMCOEI		HOWELL =	2
ALRO 2	ALTHAEA	ROSEA		GRAY =	
ALYSS	ALYSSUM			L. =ALYSSUM	
ALAL	ALYSSUM	ALYSSOIDES		L. =PALE ALYSSUM	
ALDE	ALYSSUM	DESERTORUM		STAPF. =	
AMARA	AMARANTHUS			ADANS. =AMARANTH; PIGWEED	
AMAL 2	AMARANTHUS	ALBUS		L. =	
AMCA	AMARANTHUS	CALIFORNICUS		(MOQ.) WATS. =	
AMGR	AMARANTHUS	GRAECIZANS		L. =	
AMHY	AMARANTHUS	HYBRIDUS		L. =SLIM AMARANTH	
AMRE	AMARANTHUS	RETROFLEXUS		L. =REDROOT AMARANTH	
AMBRO	AMBROSIA			L. =RAGWEED	
AMAC	AMBROSIA	ACANTHICARPA		HOOK. =	
AMAR 2	AMBROSIA	ARTEMISIFOLIA		L. =COMMON RAGWEED	
AMCH	AMBROSIA	CHAMISSONIS		GREENE =	
AMMAN	AMMANNIA			L. =AMMANNIA	
AMCO	AMMANNIA	COCCINEA		ROTTB. =	
AMORP	AMORPHA			L. =AMORPHA	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ANGE 2	ANTENNARIA	GEYERI		GRAY =	
ANLA	ANTENNARIA	LANATA		(HOOK.) GREENE =WOOLLY PUSSYTOES	
ANLU	ANTENNARIA	LUZULOIDES		T. & G. =RUSH PUSSYTOES	
ANMI	ANTENNARIA	MICROCEPHALA		RYDB. =	1
ANNE 2	ANTENNARIA	NEGLECTA		GREENE =FIELD PUSSYTOES	
ANNEA	ANTENNARIA	NEGLECTA	ATTENUATA	(FERN.) CRONQ. =	
ANNEH	ANTENNARIA	NEGLECTA	HOWELLII	CRONQ. =	
ANNEN	ANTENNARIA	NEGLECTA	NEGLECTA	GREENE =FIELD PUSSYTOES	
ANPA 3	ANTENNARIA	PARVIFOLIA		NUTT. =	
ANPU	ANTENNARIA	PULCHERRIMA		(HOOK.) GREENE =SHOWY PUSSYTOES	
ANRA	ANTENNARIA	RACEMOSA		HOOK. =RACEME PUSSYTOES	
ANRO	ANTENNARIA	ROSEA		GREENE =ROSE PUSSYTOES	
ANSP	ANTENNARIA	SPECIOSA		E. NELS. =	1
ANST	ANTENNARIA	STENOPHYLLA		GRAY =	
ANSU	ANTENNARIA	SUFFRUTESCENS		GREENE =	
ANUM	ANTENNARIA	UMBRINELLA		RYDB. =UMBER PUSSYTOES	
ANTHE	ANTHEMIS			L. =CAMOMILE	
ANCO	ANTHEMIS	COTULA		L. =MAYWEED CAMOMILE	
ANTI	ANTHEMIS	TINCTORIA		L. =	
ANTHR	ANTHRISCUS			HOFFM. =CHERVIL	
ANSC 2	ANTHRISCUS	SCANDICINA		(WEBER) MANSFELD =	
ANOR 2	ANTIRRHINUM	ORONTIUM		L. =	
APARG	APARGIDIUM			T. & G. =ASPARGIDIUM	
APBO	APARGIDIUM	BOREALE		(BONG.) T. & G. =	
APLOP	APLOPAPPUS			CASS. =GOLDENWEED	2
APOCY	APOCYNUM			L. =DOGBANE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
APAN	APOCYNUM	ANDROSAEMIFOLIUM		L.	=SPREADING DOGBANE	
APANP	APOCYNUM	ANDROSAEMIFOLIUM	PUMILUM	GRAY	=LOW DOGBANE	
APCA	APOCYNUM	CANNABINUM		L.	=HEMP DOGBANE	
APME	APOCYNUM	MEDIUM		GREENE	=	
APPU	APOCYNUM	PUMILUM		GREENE	=LOW DOGBANE	1
APSI	APOCYNUM	SIBIRICUM		JACQ.	=	
APTO	APOCYNUM	TOMENTELLUM		GREENE	=	1
AQUIL	AQUILEGIA			L.	=COLUMBINE	
AQCO	AQUILEGIA	COERULEA		JAMES	=	
AQCOC	AQUILEGIA	COERULEA	COERULEA	JAMES	=	
AQFL	AQUILEGIA	FLAVESCENS		WATS.	=YELLOW COLUMBINE	
AQFO	AQUILEGIA	FORMOSA		FISCH.	=SITKA COLUMBINE	
ARABI	ARABIS			L.	=ROCKCRESS	
ARAC	ARABIS	ACULEOLATA		GREENE	=WALL ROCKCRESS	
ARCO 4	ARABIS	COBRENSIS		M. E. JONES	=	
ARCR	ARABIS	CRUCISETOSA		CONST. & ROLLINS	=	
ARCU	ARABIS	CUSICKII		WATS.	=CUSICK ROCKCRESS	
ARDI 3	ARABIS	DIVARICARPA		A. NELS.	=	
AROR 2	ARABIS	DRUMMONDII		GRAY	=DRUMMOND ROCKCRESS	
ARFU 2	ARABIS	FURCATA		WATS.	=	
ARGL	ARABIS	GLABRA		(L.) BERNH.	=	
ARHI	ARABIS	HIRSUTA		(L.) SCOP.	=HAIRY ROCKCRESS	
ARHIG	ARABIS	HIRSUTA	GLABRATA	T. & G.	=	
ARHIH	ARABIS	HIRSUTA	HIRSUTA	(L.)SCOP.	=HAIRY ROCKCRESS	
ARHIP	ARABIS	HIRSUTA	PYCNOCARPA	(HOPKINS) ROLLINS	=COMMON HAIRY ROCKCRESS	
ARHO	ARABIS	HOLBOELLII		HORREM.	=HOLBOELL ROCKCRESS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ARHOP	ARABIS	HOLBOELLII	PENDULOCARPA	(A.NELS.) ROLLINS =	
ARHOR	ARABIS	HOLBOELLII	RECTOFRACTA	(GRAH.) RYDB. =	
ARKO	ARABIS	KOEHLERI		HOW. =RED ROCKCRESS	
ARLE	ARABIS	LEMMONII		WATS. =	
ARLI	ARABIS	LIGNIFERA		A. NELS. =	
ARLY	ARABIS	LYALLII		WATS. =LYALL ROCKCRESS	
ARLY 2	ARABIS	LYRATA		L. =	
ARMI 2	ARABIS	MICROPHYLLA		NUTT. =LITTLELEAF ROCKCRESS	
ARMO 2	ARABIS	MODESTA		ROLLINS =	
ARNU 2	ARABIS	NUTTALLII		ROBINS. =	
AROR	ARABIS	OREGANA		ROLLINS =OREGON ROCKCRESS	
ARPE	ARABIS	PERELEGANS		NELS. =	1
ARPLH	ARABIS	PLATYSPERMA	HOWELLII	(WATS.) JEPS. =	
ARPU	ARABIS	PUBERULA		NUTT. =	
ARPY	ARABIS	PYCNOCARPA		HOPKINS =	1
ARRE	ARABIS	RECTISSIMA		GREENE =BRISTLY-LEAVED ROCKCRESS	
ARSP 2	ARABIS	SPARSIFLORA		NUTT. =SICKLE-POD ROCK CRESS	
ARSU	ARABIS	SUBPINNATIFIDA		ROLLINS =	1
ARSU 2	ARABIS	SUFFRUTESCENS		WATS. =WOODY ROCKCRESS	
ARBE 2	ARAGALLUS	BESSEYI		RYDB. =	2
ARCA 3	ARALIA	CALIFORNICA		WATS. =CALIFORNIA ARALIA	
ARNU 3	ARALIA	NUDICAULIS		L. =	
ARCEU	ARCEUTHOBIUM			GRISEB. =DWARF MISTLETOE	
ARAM 2	ARCEUTHOBIUM	AMERICANUM		NUTT. EX ENGELM. =	
ARCA 6	ARCEUTHOBIUM	CAMPYLOPODUM		ENGELM. =YELLOW LEAFLESS MISTLETOE	
ARCTI	ARCTIUM			L. =BURDOCK	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ARLA 3	ARCTIUM	LAPPA		L. =	
ARMI 3	ARCTIUM	MINUS		(HILL) BERNH. =	
ARENA	ARENARIA			L. =SANDWORT	
ARAC 2	ARENARIA	ACULEATA		WATS. =	
ARBU	ARENARIA	BURKEI		HOW. =BURKE SANDWORT	1
ARCA 2	ARENARIA	CAPILLARIS		POIR. =SANDWORT	
ARCAA	ARENARIA	CAPILLARIS	AMERICANA	(MAG.) DAVIS =	
ARCAC	ARENARIA	CAPILLARIS	CAPILLARIS	POIR. =SANDWORT	
ARCO 2	ARENARIA	CONGESTA		NUTT. =BALLHEAD SANDWORT	
ARDO 2	ARENARIA	DOUGLASII		FENZL. =DOUGLAS SANDWORT	
ARFO 2	ARENARIA	FORMOSA		FISCH. =FESCUE SANDWORT	1
ARFR 2	ARENARIA	FRANKLINII		DOUGL. EX HOOK. =FRANKLINS SANDWORT	
ARHO 2	ARENARIA	HOWELLII		WATS. =HOWELL S SANDWORT	
ARKI	ARENARIA	KINGII		(WATS.) M. E. JONES =	
ARKIU	ARENARIA	KINGII	UINTAHENSIS	(A. NELS.) C. L. HITCHC. =	
ARLA 2	ARENARIA	LATERIFLORA		L. =BLUNTLEAF SANDWORT	
ARMA 3	ARENARIA	MACROPHYLLA		HOOK. =	
ARNU	ARENARIA	NUTTALLII		PAX =	
AROB	ARENARIA	OBTUSILOBA		(RYDB.) FERN. =	
ARPA 4	ARENARIA	PALUDICOLA		ROBINS. =	
ARPU 2	ARENARIA	PUMICOLA		COV. & LEIB. =CRATER LAKE SANDWORT	
ARPU 3	ARENARIA	PUSILLA		WATS. =	
ARRO	ARENARIA	ROSSII		R. BR. =	
ARRU	ARENARIA	RUBELLA		(WAHLENB.) J. E. SM. =	
ARSA	ARENARIA	SAJANENSIS		AUTHORS NOT SCHLECHT. =SIBERIAN SANDWORT	1
ARSE	ARENARIA	SERPYLLIFOLIA		L. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ARST	ARENARIA	STRICTA		MICHX. =	
ARUI	ARENARIA	UINTAHENSIS		A. NELS. =UINTA SANDWORT	1
ARMER	ARMERIA			DC. =THRIFT; SEA-PINK	
ARMAC	ARMERIA	MARITIMA	CALIFORNICA	(BOISS.) LAWRENCE =CALIFORNIA COMMON THRIFT	
ARNIC	ARNICA			L. =ARNICA	
ARAM	ARNICA	AMPLEXICAULIS		NUTT. =	
ARAU	ARNICA	AURANTIACA		GREENE =RYDBERG ARNICA	1
ARBE	ARNICA	BETONICAEFOLIA		GREENE =BETONY ARNICA	1
ARCH	ARNICA	CHAMISSONIS		LESS. =CHAMISSO ARNICA	
ARCHF	ARNICA	CHAMISSONIS	FOLIOSA	(NUTT.) MAGUIRE =	
ARCHI	ARNICA	CHAMISSONIS	INCANA	(GRAY)HULT. =	
ARCO	ARNICA	CORDIFOLIA		HOOK. =HEARTLEAF ARNICA	
ARDI	ARNICA	DISCOIDEA		BENTH. =	
ARDIE	ARNICA	DISCOIDEA	ERADIATA	(GRAY) CRONQ. =	
ARDI 2	ARNICA	DIVERSIFOLIA		GREENE =	
ARFO	ARNICA	FOLIOSA		NUTT. =LEAFY ARNICA	1
ARFU	ARNICA	FULGENS		PURSH =ORANGE ARNICA	
ARLA	ARNICA	LATIFOLIA		BONG. =BROADLEAF ARNICA	
ARLAG	ARNICA	LATIFOLIA	GRACILIS	(RYDB.) CRONQ. =	
ARLAL	ARNICA	LATIFOLIA	LATIFOLIA	BONG. =BROADLEAF ARNICA	
ARLO	ARNICA	LONGIFOLIA		D. C. EAT. =LONGLEAF ARNICA	
ARMA 2	ARNICA	MACOUNII		GREENE =	1
ARMO	ARNICA	MOLLIS		HOOK. =HAIRY ARNICA	
ARNE 2	ARNICA	NEVADENSIS		GRAY =	
ARPA 3	ARNICA	PARRYI		GRAY =RAYLESS ARNICA	
ARPA 2	ARNICA	PARVIFLORA		GRAY =	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ARRY	ARNICA	RYDBERGII		GREENE =RYDBERG ARNICA	
ARSO	ARNICA	SORORIA		GREENE =	
ARTEM2	ARTEMISIA			L. =SAGE; WORMWOOD	
ARAB	ARTEMISIA	ABSINTHIUM		L. =	
ARBI	ARTEMISIA	BIENNIS		WILLD. =	
ARCA 4	ARTEMISIA	CAMPESTRIS		L. =	
ARCAC3	ARTEMISIA	CAMPESTRIS	CAMPESTRIS	L. =	
ARCAS	ARTEMISIA	CAMPESTRIS	SCOULERIANA	(BESS.) CRONQ. =	
ARCAW	ARTEMISIA	CAMPESTRIS	WORMSKIOLDII	(BESS.) CRONQ. =	
ARDO	ARTEMISIA	DOUGLASIANA		BESS. =	
ARDR	ARTEMISIA	DRACUNCULUS		L. =TARRAGON	
ARGN	ARTEMISIA	GNAPHALODES		NUTT. =CUDWEED SAGEBRUSH	1
ARLI 2	ARTEMISIA	LINDLEYANA		BESS. =	
ARLU	ARTEMISIA	LUDOVICIANA		NUTT. =LOUISIANA SAGEBRUSH; HERBACEOUS SAGE	
ARLUI	ARTEMISIA	LUDOVICIANA	INCOMPTA	(NUTT.) CRONQ. =	
ARLUL	ARTEMISIA	LUDOVICINA	LATILOBA	NUTT. =	
ARMI	ARTEMISIA	MICHAUXIANA		BESS. =MICHAUX SAGEBRUSH	
ARNO	ARTEMISIA	NORVEGICA		FRIES =	
ARSU 3	ARTEMISIA	SUKSDORFII		PIPER =	
ARTI	ARTEMISIA	TILESII		LEDEB. =	
ARTIU	ARTEMISIA	TILESII	UNALASCHCENSIS	BESS. =	
ARTR 3	ARTEMISIA	TRIFURCATA		STEPH. EX SPRENG. =	
ARVU 2	ARTEMISIA	VULGARIS		L. =	
ARUNC	ARUNCUS			ADANS. =GOATSBEARD	
ARSY	ARUNCUS	SYLVESTER		KOSTEL. =SYLVAN GOATSBEARD	
ARVU	ARUNCUS	VULGARIS		RAF. =	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ASARU	ASARUM			L. =WILDGINGER	
ASCA 3	ASARUM	CAUDATUM		LINDL. =BRITISH COLUMBIA WILDGINGER	
ASHA	ASARUM	HARTWEGI		WATS. =WILD-GINGER	
ASCLE	ASCLEPIAS			L. =MILKWEED	
ASCO 4	ASCLEPIAS	CORDIFOLIA		(BENTH.) JEPS. =	
ASCR	ASCLEPIAS	CRYPTOCERAS		WATS. =PALLID MILKWEED	
ASFA 2	ASCLEPIAS	FASCICULARIS		DCNE. =MEXICAN MILKWEED	
ASME	ASCLEPIAS	MEXICANA		AUTHORS NOT CAV. =	1
ASSP	ASCLEPIAS	SPECIOSA		TORR. =SHOWY MILKWEED	
ASPAR	ASPARAGUS			L. =ASPARAGUS	
ASOF	ASPARAGUS	OFFICINALIS		L. =	
ASPER	ASPERUGO			L. =MADWORT; CATCHWEED	
ASPR	ASPERUGO	PROCUMBENS		L. =	
ASPER2	ASPERULA			L. =WOODRUFF	
ASHU	ASPERULA	HUMIFUSA		(BIEB.) BESS. =	
ASOD	ASPERULA	ODORATA		L. =	
ASPLE	ASPLENIUM			L. =SPLEENWORT	
ASTR	ASPLENIUM	TRICHOMANES		L. =	
ASVI	ASPLENIUM	VIRIDE		HUDS. =	
ASTER	ASTER			L. =ASTER	
ASAD	ASTER	ADSCENDENS		LINDL. =LONGLEAF ASTER	1
ASAL	ASTER	ALPIGENUS		(T. & G.) GRAY =	
ASALA	ASTER	ALPIGENUS	ALPIGENUS	(T. & G.) GRAY =	
ASALA2	ASTER	ALPIGENUS	ANDERSONII	(GRAY) PECK =	
ASALH	ASTER	ALPIGENUS	HAYDENII	(PORTER) CRONQ. =	
ASBR 2	ASTER	BRACHYACTIS		BLAKE =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ASBR	ASTER	BRICKELLIOIDES		GREENE =	
ASCA 2	ASTER	CAMPESTRIS		NUTT. =	
ASCA	ASTER	CANESCENS		PURSH =HOARY ASTER	2
ASCH	ASTER	CHILENSIS		NEES =PACIFIC ASTER	
ASCO	ASTER	CONSPICUUS		LINDL. =SHOWY ASTER	
ASCU	ASTER	CURTUS		CRONQ. =CURTUS ASTER	
ASCU 3	ASTER	CUSICKII		GRAY =CUSICK ASTER	1
ASEA	ASTER	EATONII		(GRAY) HOW. =EATONS ASTER	
ASEN	ASTER	ENGELMANNI		(EAT.) GRAY =ENGELMANN ASTER	
ASFO	ASTER	FOLIACEUS		LINDL. =LEAFYBRACT ASTER	
ASFOA	ASTER	FOLIACEUS	APRICUS	GRAY =	
ASFOC	ASTER	FOLIACEUS	CUSICKII	(GRAY) CRONQ. =	
ASFOL	ASTER	FOLIACEUS	LYALLII	(GRAY) CRONQ. =	
ASFOP	ASTER	FOLIACEUS	PARRYI	(D. C. EAT.) GRAY =	
ASFR	ASTER	FREMONTI		GRAY =FREMONT ASTER	1
ASFR 2	ASTER	FRONDOSUS		(NUTT.) T. & G. =	
ASGL 2	ASTER	GLAUCESCENS		(GRAY) BLAKE =	
ASGO	ASTER	GORMANII		(PIPER) BLAKE =	
ASIN	ASTER	INTEGRIFOLIUS		NUTT. =THICKSTEM ASTER	
ASJE	ASTER	JESSICAE		PIPER =JESSICA ASTER	
ASLE 2	ASTER	LEDOPHYLLUS		GRAY =CASCADES ASTER	
ASLEC2	ASTER	LEDOPHYLLUS	COVILLEI	(GREENE) CRONQ. =	
ASLE 5	ASTER	LEIODES		BLAKE =	2
ASMO	ASTER	MODESTUS		LINDL. =FEWFLOWER ASTER	
ASOC	ASTER	OCCIDENTALIS		(NUTT.) T. & G. =WESTERN ASTER	
ASOCI	ASTER	OCCIDENTALIS	INTERMEDIUS	GRAY =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
ASOCO	ASTER	OCCIDENTALIS	OCCIDENTALIS	(NUTT.)T. & G.	=WESTERN ASTER	
ASOR 2	ASTER	OREGONENSIS		(NUTT.) CRONQ.	=	
ASPA 4	ASTER	PANSUS		(BLAKE) CRONQ.	=	
ASPA	ASTER	PAUCICAPITATUS		ROB.	=	
ASPE	ASTER	PERELEGANS		NELS. & MACBR.	=NUTTALL ASTER	
ASRA	ASTER	RADULINUS		GRAY	=	
ASSC	ASTER	SCOPULORUM		GRAY	=CRAG ASTER	
ASSH	ASTER	SHASTENSIS		GRAY	=	2
ASSI 2	ASTER	SIBIRCUS		L.	=	
ASST 2	ASTER	STENOMERES		GRAY	=	
ASSU 2	ASTER	SUBSPICATUS		NEES	=DOUGLAS ASTER	
ASTE 5	ASTER	TEPHRODES		BLAKE	=	2
ASVI 2	ASTER	VIALIS		(BRADSHAW) BLAKE	=	
ASTRA	ASTRAGALUS			L.	=MILKVETCH; POISONVETCH; LOCOWEED; RATTLEPOD	
ASAB	ASTRAGALUS	ABORIGINUM		RICHARDS.	=	
ASAD 2	ASTRAGALUS	ACANUS		A. NELS.	=	
ASADR	ASTRAGALUS	ADSURGENS	ROBUSTIOR	HOOK.	=	
ASAG	ASTRAGALUS	AGRESTIS		DOUGL. EX G.DON	=PURPLE MILKVETCH	
ASAG 2	ASTRAGALUS	AGRESTIS		DOUGL. EX G. DON	=	
ASAL 2	ASTRAGALUS	ALPINUS		L.	=ALPINE MILKVETCH	
ASAM	ASTRAGALUS	AMBLYTROPIS		BARNEBY	=	
ASAM 2	ASTRAGALUS	AMNIS-AMISSI		BARNEBY	=	
ASAR 2	ASTRAGALUS	ARGOPHYLLUS		NUTT.	=	
ASARA	ASTRAGALUS	ARGOPHYLLUS	ARGOPHYLLUS	NUTT.	=	
ASARP	ASTRAGALUS	ARGOPHYLLUS	PEPHRAGMENOIDES	BARNEBY	=	
ASAR	ASTRAGALUS	ARRECTUS		GRAY	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ASAR 3	ASTRAGALUS	ARTHURI		M. E. JONES =	
ASAT	ASTRAGALUS	ATRATUS		WATS. =	
ASATO	ASTRAGALUS	ATRATUS	OWYHEENSIS	(NELS. & MACBR.) M. E. JONES =	
ASAT 2	ASTRAGALUS	ATROPUBESCENS		COULT. & FISHER =	
ASBE	ASTRAGALUS	BECKWITHII		T. & G. =BECKWITH MILKVETCH	
ASBEW	ASTRAGALUS	BECKWITHII	WEISERENSIS	M. E. JONES =	
ASBO	ASTRAGALUS	BOURGOVII		GRAY =	
ASCA 4	ASTRAGALUS	CALYCOSUS		TORR. EX WATS. =	
ASCA 7	ASTRAGALUS	CANADENSIS		L. =	
ASCAM	ASTRAGALUS	CANADENSIS	MORTONI	(NUTT.) WATS. =CANADA MILKVETCH	
ASCA 5	ASTRAGALUS	CARICINUS		(M. E. JONES) BARNEBY =	
ASCE	ASTRAGALUS	CERAMICUS		SHELD. =	
ASCI 2	ASTRAGALUS	CIBARIUS		SHELD. =	
ASCI	ASTRAGALUS	CICER		L. =CHICKPEA MILKVETCH	
ASCO 2	ASTRAGALUS	COLLINUS		DOUGL. EX HOOK. =	
ASCOC	ASTRAGALUS	COLLINUS	COLLINUS	DOUGL. EX HOOK. =HILLSIDE MILK VETCH	
ASCOL	ASTRAGALUS	COLLINUS	LAURENTII	(RYDB.) BARNEBY =	
ASCO 6	ASTRAGALUS	COLUMBIANUS		BARNEBY =	
ASCO 3	ASTRAGALUS	CONJUNCTUS		WATS. =	1
ASCO 9	ASTRAGALUS	CONJUNCTUS		WATS. =	
ASCO 5	ASTRAGALUS	CONVALLARIUS		GREENE =TIMBER POISONVETCH	
ASCO 8	ASTRAGALUS	COTTONII		M. E. JONES =	
ASCU 2	ASTRAGALUS	CURVICARPUS		(SHELD.) MACBR. =CURVEPOD LOCO	
ASCUC	ASTRAGALUS	CURVICARPUS	CURVICARPUS	(SHELD.) MACBR. =CURVEPOD MILK VETCH	
ASCUS	ASTRAGALUS	CURVICARPUS	SUBGLABER	(RYDB.) BARNEBY =	
ASCU 4	ASTRAGALUS	CUSICKII		GRAY =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME ALTHORSHIP COMMON NAME	S C
ASCUC2	ASTRAGALUS	CUSICKII	CUSICKII	GRAY =	
ASCUF	ASTRAGALUS	CUSICKII	FLEXILIPES	BARNEBY =	
ASDA	ASTRAGALUS	DASYGLOTTIS		(FISCH.) EX DC. =	1
ASDI	ASTRAGALUS	DIAPHANUS		DOUGL. EX HOOK. =	
ASDI 2	ASTRAGALUS	DIURNUS		WATS. =	1
ASDI 3	ASTRAGALUS	DIVERSIFOLIUS		GRAY =	
ASDR	ASTRAGALUS	DRUMMONDII		HOOK. =	
ASER	ASTRAGALUS	EREMITICUS		SHELD. =	
ASERS	ASTRAGALUS	EREMITICUS	SPENCIANUS	M.E.JONES =	
ASFA	ASTRAGALUS	FALCATUS		LAM. =	
ASFI	ASTRAGALUS	FILIPES		TORR. EX GRAY =	
ASGE	ASTRAGALUS	GEYERI		GRAY =	
ASGL	ASTRAGALUS	GLAREOSUS		DOUGL. EX HOOK. =	1
ASHO	ASTRAGALUS	HOODIANUS		HAV. =	1
ASHO 2	ASTRAGALUS	HOWELLII		GRAY =HOWELL MILK VETCH	
ASIM	ASTRAGALUS	IMPENSUS		WOOT. & STANDL. =THISTLE MILKVETCH	1
ASIN 2	ASTRAGALUS	INFLEXUS		DOUGL. EX HOOK. =	
ASIN 3	ASTRAGALUS	INVERSUS		JONES =	
ASKE	ASTRAGALUS	KENTROPHYTA		GRAY =	
ASKED	ASTRAGALUS	KENTROPHYTA	DOUGLASII	BARNEBY =	
ASKEE	ASTRAGALUS	KENTROPHYTA	ELATUS	WATS. =	
ASLE 3	ASTRAGALUS	LEIBERGII		M. E. JONES =	
ASLE 4	ASTRAGALUS	LEMMONII		GRAY =	
ASLE	ASTRAGALUS	LENTIGINOSUS		DOUGL. EX HOOK. =SPECKLEPOD LOCO	
ASLEC	ASTRAGALUS	LENTIGINOSUS	CARINATUS	M. E. JONES =	
ASLEP	ASTRAGALUS	LENTIGINOSUS	PLATYPHYLLIDIUS	(RYDB.) PECK =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ASLE 6	ASTRAGALUS	LEPTALEUS		GRAY =	
ASLY	ASTRAGALUS	LYALLII		GRAY =	
ASLYL	ASTRAGALUS	LYALLII	LYALLII	GRAY =	
ASMA	ASTRAGALUS	MACOUNII		RYDB. =	1
ASMA 2	ASTRAGALUS	MALACUS		GRAY =	
ASMI 2	ASTRAGALUS	MICROCYSTIS		GRAY =	
ASMI	ASTRAGALUS	MISER		DOUGL. EX HOOK. =STARVED MILK VETCH	
ASMIM	ASTRAGALUS	MISER	MISER	DOUGL. EX HOOK. =STARVED MILK VETCH	
ASMIP	ASTRAGALUS	MISER	PRACTERITUS	BARNEBY =	
ASMO 2	ASTRAGALUS	MCRTONI		NUTT. =MCRTON LOCO	1
ASMU	ASTRAGALUS	MULFORDIAE		M. E. JONES =	
ASNE	ASTRAGALUS	NEWBERRYI		GRAY =	
ASNU	ASTRAGALUS	NUDISILIQUUS		A. NELS. =	
ASOB	ASTRAGALUS	OBSCURUS		WATS. =	
ASON	ASTRAGALUS	ONICIFORMIS		BARNEBY =	
ASOR	ASTRAGALUS	OREGANUS		NUTT. EX T. & G. =	
ASPA 2	ASTRAGALUS	PALOUSENSIS		PIPER =	
ASPA 3	ASTRAGALUS	PAYSONII		(RYDB.) BARNEBY =	
ASPL	ASTRAGALUS	PLATYTROPIS		GRAY =	
ASPU 2	ASTRAGALUS	PULSIFERAE		GRAY =	
ASPU	ASTRAGALUS	PURSHII		DOUGL. EX HOOK. =PURSH LOCO	
ASPUC	ASTRAGALUS	PURSHII	CONCINNUS	BARNEBY =	
ASPUG	ASTRAGALUS	PURSHII	GLAREOSUS	(DOUGL.) BARNEBY =	
ASPUL	ASTRAGALUS	PURSHII	LAGOPINUS	(RYDB.) BARNEBY =	
ASPUO	ASTRAGALUS	PURSHII	OPHIOGENES	BARNEBY =	
ASPUP	ASTRAGALUS	PURSHII	PURSHII	DOUGL. EX HOOK. =PURSH MILK VETCH	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ASPUT	ASTRAGALUS	PURSHII	TINCTUS	M. E. JONES =	
ASRE 2	ASTRAGALUS	REVENTIFORMIS		BARNEBY =	
ASRE	ASTRAGALUS	REVENTUS		GRAY =	
ASREC	ASTRAGALUS	REVENTUS	CONJUNCTUS	(WATS.) M. E. JONES =	
ASREO	ASTRAGALUS	REVENTUS	OXYTROPIDOIDES	(M. E. JONES) C. L. HITCHC. =	
ASRER	ASTRAGALUS	REVENTUS	REVENTUS	GRAY =	
ASRES	ASTRAGALUS	REVENTUS	SHELDONII	(RYDB.) C. L. HITCHC. =	
ASRI	ASTRAGALUS	RIPARIUS		BARNEBY =	
ASRO	ASTRAGALUS	ROBBINSII		(OAKES) GRAY =	
ASROA	ASTRAGALUS	ROBBINSII	ALPINIFORMIS	(RYDB.) BARNEBY =	
ASROO	ASTRAGALUS	ROBBINSII	OCCIDENTALIS	WATS. =	
ASSA	ASTRAGALUS	SALINUS		HOW. =	1
ASSA 2	ASTRAGALUS	SALMONIS		M. E. JONES =SALMON MILK VETCH	
ASSC 3	ASTRAGALUS	SCAPHOIDES		M. E. JONES =	
ASSC 2	ASTRAGALUS	SCLEROCARPUS		GRAY =STALKED-POD MILK VETCH	
ASSI	ASTRAGALUS	SINUATUS		PIPER =	
ASSO	ASTRAGALUS	SONNEANUS		GREENE =BALLOONPOD MILKVETCH	1
ASSP 2	ASTRAGALUS	SPALDINGII		GRAY =SPALDINGS MILK VETCH	
ASSPT	ASTRAGALUS	SPALDINGII	TYGHENSIS	(PECK) C. L. HITCHC. =	1
ASSP 3	ASTRAGALUS	SPEIROCARPUS		GRAY =	1
ASST	ASTRAGALUS	STENOPHYLLUS		T. & G. =	1
ASSTF	ASTRAGALUS	STENOPHYLLUS	FILIPES	TORR. EX GRAY =	1
ASSU	ASTRAGALUS	SUCCUMBENS		DOUGL. EX HOOK. =COLUMBIA MILK VETCH	
ASTE	ASTRAGALUS	TEGETARIOIDES		M. E. JONES =	
ASTE 3	ASTRAGALUS	TENELLUS		PURSH =	
ASTE 4	ASTRAGALUS	TERMINALIS		WATS. =	

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ASTO	ASTRAGALUS	TOANUS		M. E. JONES =	
ASTW	ASTRAGALUS	TWEEDYI		CANBY =TWEEDY MILK VETCH	
ASTY	ASTRAGALUS	TYGHENSIS		PECK =	
ASVA	ASTRAGALUS	VALLARIS		M. E. JONES =	
ASVE	ASTRAGALUS	VEXILLIFLEXUS		SHELD. =	
ASWA	ASTRAGALUS	WATSONIANUS		SHELD. =	1
ASWH	ASTRAGALUS	WHITNEYI		GRAY =	
ATHYR	ATHYRIUM			ROTH. =LADYFERN	
ATCY	ATHYRIUM	CYCLOSORUM		ATTR. TO RUPR. =	1
ATDI	ATHYRIUM	DISTENTIFOLIUM		TAUSCH EX OPIZ =	
ATDIA	ATHYRIUM	DISTENTIFOLIUM	AMERICANUM	(BUTTERS) CRONQ. =	
ATFI	ATHYRIUM	FILIX-FEMINA		(L.) ROTH. =LADYFERN	
ATHYS	ATHYSANUS			GREENE =SANDWEED	
ATPU	ATHYSANUS	PUSILLUS		(HOOK.) GREENE =	
ATRIP2	ATRIPLEX			L. =SALTBUSH	
ATAR	ATRIPLEX	ARGENTEA		NUTT. =	
ATPA	ATRIPLEX	PATULA		L. =	
ATPAH	ATRIPLEX	PATULA	HASTATA	(L.) GRAY =SPEARLEAF FAT-HEN SALTBUSH	
ATPAP	ATRIPLEX	PATULA	PATULA	L. =	
ATRO	ATRIPLEX	ROSEA		L. =TUMBLING ORACH	
ATTR	ATRIPLEX	TRUNCATA		(TORR.) GRAY =	
AZOLL	AZOLLA			LAM. =AZOLLA	
AZFI	AZOLLA	FILICULOIDES		LAM. =PACIFIC AZOLLA	
AZME	AZOLLA	MEXICANA		PRESL =	
BAERI	BAERIA			FISCH. & MEY. =GOLDFIELDS	
BAMAP	BAERIA	MACRANTHA	FAUCIARISTATA	GRAY =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
BAMA	BAERIA	MARITIMA		GRAY =	2
BALSA	BALSAMORHIZA			HOOK. =BALSAMROOT	
BACA	BALSAMORHIZA	CAREYANA		GRAY =CAREY BALSAMROOT	
BACAC	BALSAMORHIZA	CAREYANA	CAREYANA	GRAY =CAREY BALSAMROOT	
BACAI	BALSAMORHIZA	CAREYANA	INTERMEDIA	CRONQ. =	
BADE	BALSAMORHIZA	DELTOIDEA		NUTT. =PUGET BALSAMROOT	
BAHI	BALSAMORHIZA	HIRSUTA		NUTT. =HAIRY BALSAMROOT	
BAHO	BALSAMORHIZA	HOOKERI		NUTT. =HOOKER BALSAMROOT	
BAIN	BALSAMORHIZA	INCANA		NUTT. =HOARY BALSAMROOT	
BAMA 2	BALSAMORHIZA	MACROPHYLLA		NUTT. =	
BARO	BALSAMORHIZA	ROSEA		NELS. & MACBR. =	
BASA	BALSAMORHIZA	SAGITTATA		(PURSH) NUTT. =ARROWLEAF BALSAMROOT	
BASE	BALSAMORHIZA	SERRATA		NELS. & MACBR. =SERRATED BALSAMROOT	
BATE	BALSAMORHIZA	TEREBINTHACEA		(HOOK.) NUTT. =	1
BARBA	BARBAREA			R. BR. =WINTERCRESS	
BAAM	BARBAREA	AMERICANA		RYDB. =	1
BAOR	BARBAREA	ORTHOCERAS		LEDEB. =	
BAST	BARBAREA	STRICTA		AUTHORS NOT ANDRZ. =	1
BAVE	BARBAREA	VERNA		(MILL.) ASCH. =EARLY WINTERCRESS	
BAVU	BARBAREA	VULGARIS		R. BR. =BITTER WINTERCRESS	
BASSI	BASSIA			ALL. =BASSIA	
BAHY	BASSIA	HYSSOPIFOLIA		(PALL.) KUNTZE =	
BELLI	BELLIS			L. =BELLIS	
BEPE	BELLIS	PERENNIS		L. =	
BERGI	BERGIA			L. =BERGIA	
BETE	BERGIA	TEXANA		(HOOK.) SEUBERT =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
BERUL	BERULA			HOFFM. =BERULA	
BEER	BERULA	ERECTA		(HUDS.) COV. =STALKY BERULA	
BESSE	BESSEYA			RYDB. =BESSEYA	
BERU	BESSEYA	RUBRA		(DOUGL.) RYDB. =	
BEWY	BESSEYA	WYOMINGENSIS		(A. NELS.) RYDB. =	
BIDEN	BIDENS			L. =BEGGARS-TICKS	
BIBE	BIDENS	BECKII		TORR. EX SPRENG. =	
BICE	BIDENS	CERNUA		L. =NODDING BEGGARS-TICKS	
BIFR	BIDENS	FRONDOSA		L. =	
BITR	BIDENS	TRIPARTITA		L. =	
BIVU	BIDENS	VULGATA		GREENE =TALL BEGGARS-TICKS	
BLECH	BLECHNUM			JUSS. =DEERFERN	
BLSP	BLECHNUM	SPICANT		(L.) WITH. =DEERFERN	
BLEPH	BLEPHARIPAPPUS			HOOK. =BLEPHARIPAPPUS	
BLSC	BLEPHARIPAPPUS	SCABER		HOOK. =	
BOISD	BOISDUVALIA			SPACH =SPIKEPRIMROSE	
BODE	BOISDUVALIA	DENSIFLORA		(LINDL.) WATS. =DENSE SPIKEPRIMROSE	
BODED	BOISDUVALIA	DENSIFLORA	DENSIFLORA	(LINDL.)WATS. =DENSE SPIKEPRIMROSE	
BODES	BOISDUVALIA	DENSIFLORA	SALICINA	MUNZ =	
BOGA	BOISDUVALIA	GALBELLA		(NUTT.) WALPERS =	
BOSP	BOISDUVALIA	SPARSIFLORA		HELLER =	1
BOST	BOISDUVALIA	STRICTA		(GRAY) GREENE =BROOK SPIKEPRIMROSE	
BOLTO	BOLTONIA			L'HER. =BOLTONIA	
BOAS	BOLTONIA	ASTEOIDES		(L.) L'HER. =	
BORAG	BORAGO			L. =BORAGE	
BOOF	BORAGO	OFFICINALIS		L. =	

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BOSCH	BOSCHNIAKIA			C. A. MEY.	=GROUND-CONE	
BOHO	BOSCHNIAKIA	HOOKERI		WALPERS	=	
BOST 2	BOSCHNIAKIA	STROBILACEA		GRAY	=GROUND CONE	
BOTRY	BOTRYCHIUM			SWARTZ.	=GRAPEFERN	
BOBO	BOTRYCHIUM	BOREALE		MILDE	=	
BOLA	BOTRYCHIUM	LANCEOLATUM		(GMEL.) ANGSTROM	=	
BOLU	BOTRYCHIUM	LUNARIA		(L.) SWARTZ	=	
BOMU	BOTRYCHIUM	MULTIFIDUM		(GMEL.) TREVIS.	=	
BOSI	BOTRYCHIUM	SILAIFOLIUM		PRESL.	=	1
BOSI 2	BOTRYCHIUM	SIMPLEX		E. HITCH.	=	
BOVI	BOTRYCHIUM	VIRGINIANUM		(L.) SWARTZ.	=	
BOYKI	BOYKINIA			NUTT.	=BOYKINIA	
BOEL	BOYKINIA	ELATA		(NUTT.) GREENE	=SANTALUCIA BOYKINIA	
BOIN	BOYKINIA	INTERMEDIA		G.N.JONES	=	1
BOMA	BOYKINIA	MAJOR		GRAY	=SIERRA BOYKINIA	
BRASS	BRASSICA			L.	=MUSTARD; BIRDRAPE	
BRCA 2	BRASSICA	CAMPESTRIS		L.	=BIRD RAPE	
BRHI	BRASSICA	HIRTA		MOENCH	=	
BRNI	BRASSICA	NIGRA		(L.) KOCH	=	
BRICK	BRICKELLIA			ELL.	=BRICKELLIA; BRICKELLBUSH	
BRGR 2	BRICKELLIA	GRANDIFLORA		(HOOK.) NUTT.	=	
BRMI 2	BRICKELLIA	MICROPHYLLA		(NUTT.) GRAY	=	
BROB	BRICKELLIA	OBLONGIFOLIA		NUTT.	=	
BROBL	BRICKELLIA	OBLONGIFOLIA	LINIFOLIA	(D. C. EAT) ROB.	=NARROW-LEAVED BRICKELLIA	
BRODI	BRODIAEA			SMITH	=BRODIEA	
BRCA 3	BRODIAEA	CAPITATA		BENTH.	=BLUEDICKS BRODIEA	

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BRCO 3	BRODIAEA	CONGESTA		SMITH =	
BRCO 2	BRODIAEA	CORONARIA		(SALISB.) ENGL. =HARVEST BRODIEA	
BRDO	BRODIAEA	DOUGLASII		WATS. =DOUGLAS BRODIEA	
BREL	BRODIAEA	ELEGANS		HOOVER =	
BRGR	BRODIAEA	GRACILIS		WATS. =	
BRHE	BRODIAEA	HENDERSONI		WATS. =HENDERSON BRODIEA	
BRHO	BRODIAEA	HOWELLII		WATS. =	
BRHY	BRODIAEA	HYACINTHINA		(LINDL.) BAKER =HYACINTH BRODIEA	
BRLA 2	BRODIAEA	LAXA		(BENTH.) WATS. =GRASSNUT BRODIEA	
BRMU	BRODIAEA	MULTIFLORA		BENTH. =MANY FLOWERED BRODIAEA	
BRPU	BRODIAEA	PULCHELLA		(SALISB.) GREEN =PURPLEHEAD BRODIEA	
BRYON	BRYONIA			L. =BRYONIA	
BRAL	BRYONIA	ALBA		L. =	
BUPLE	BUPLEURUM			L. =BUPLEURUM	
BUAM	BUPLEURUM	AMERICANUM		COULT. & ROSE =	
BUTOM	BUTOMUS			L. =FLOWERING-RUSH	
BUUM	BUTOMUS	UMBELLATUS		L. =	
CANA	CACALIOPSIS	NARDOSMIA		GRAY =	2
CAMA 5	CAKILE	MARITIMA		SCOP. =	
CALAN	CALANDRINIA			H. =ROCKPURSLANE	
CACA 5	CALANDRINIA	CAULESCENS		AUTHORS NOT H. B. K. =DESERT ROCKPURSLANE	
CACI	CALANDRINIA	CILIATA		(R. & P.) DC. =	
CAHE 2	CALITRICHE	HERMAPHRODITICA		L. =	
CALLI	CALLITRICHE			L. =WATER-STARWORT	
CAAN 3	CALLITRICHE	ANCEPS		FERN. =	
CAFA	CALLITRICHE	FASSETTII		SCHOTSMAN =	

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CAMA 6	CALLITRICHE	MARGINATA		TORR.	=	
CAST 6	CALLITRICHE	STAGNALIS		SCOP.	=	
CAVE 2	CALLITRICHE	VERNA		L.	=	
CALOC	CALOCHORTUS			PURSH	=MARIPOSA; SEGO LILY	
CAAP	CALOCHORTUS	APICULATUS		BAKER	=	
CABR 3	CALOCHORTUS	BRUNEAUNIS		NELS. & MACBR.	=	
CAEL	CALOCHORTUS	ELEGANS		PURSH	=NORTHWESTERN MARIPOSA	
CAEU 2	CALOCHORTUS	EURYCARPUS		WATS.	=	
CALO	CALOCHORTUS	LOBBII		PURDY	=LOBBS MARIPOSA	1
CALO 3	CALOCHORTUS	LONGEBARBATUS		WATS.	=	
CALOL	CALOCHORTUS	LONGEBARBATUS	LONGEBARBATUS	WATS.	=	
CALOP	CALOCHORTUS	LONGEBARBATUS	PECKII	OWNBEY	=	
CALY	CALOCHORTUS	LYALLII		BAKER	=LYALL MARIPOSA	
CAMA	CALOCHORTUS	MACROCARPUS		DOUGL.	=SAGEBRUSH MARIPOSA	1
CAMA 3	CALOCHORTUS	MAWEANUS		LEICHTL. EX BAKER	=	
CANI	CALOCHORTUS	NITIDUS		DOUGL.	=BROADFRUIT MARIPOSA	
CANU 2	CALOCHORTUS	NUTTALLII		T. & G.	=SEGOLILY MARIPOSA	
CASU 6	CALOCHORTUS	SUBALPINUS		PIPER	=	
CATO	CALOCHORTUS	TOLMIEI		H. & A.	=TOLMIE MARIPOSA	
CAUN	CALOCHORTUS	UNIFLORUS		H. & A.	=MONTEREY MARIPOSA	
CALTH	CALTHA			L.	=MARSHMARIGOLD	
CAAS	CALTHA	ASARIFOLIA		DC.	=	
CABI	CALTHA	BIFLORA		DC.	=TWINFLOWER MARSHMARIGOLD	
CALE 2	CALTHA	LEPTOSEPALA		DC.	=ELKSLIP MARSHMARIGOLD	
CALYC	CALYCADENIA			DC.	=TACKWEED	
CATR	CALYCADENIA	TRUNCATA		DC.	=	

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CALYP	CALYPSO			SALISB.	=CALYPSO; FAIRY-SLIPPER	
CABU 2	CALYPSO	BULBOSA		(L.) OAKES	=CALYPSO	
CALYP2	CALYPTRIDIUM			NUTT.	=CALYPTRIDIUM	
CARO 4	CALYPTRIDIUM	ROSEUM		WATS.	=	
CAMAS	CAMASSIA			LINDL.	=CAMAS	
CACU	CAMASSIA	CUSICKII		WATS.	=CUSICK CAMAS	
CALEL3	CAMASSIA	LEICHLINII	LEICHLINII	(BAKER) WATS.	=	
CALE	CAMASSIA	LEICHTLINII		(BAKER) WATS.	=LEICHTLIN CAMAS	
CALES	CAMASSIA	LEICHTLINII	SUKSDORFII	(GREENM.) C. L. HITCHC.	=	
CAQU	CAMASSIA	QUAMASH		(PURSH) GREENE	=COMMON CAMAS	
CAQUA	CAMASSIA	QUAMASH	AZUREA	(HELLER) C. L. HITCHC.	=	
CAQUB	CAMASSIA	QUAMASH	BREVIFLORA	(GOULD) C. L. HITCHC.	=	
CAQUI	CAMASSIA	QUAMASH	INTERMEDIA	(GOULD) C. L. HITCHC.	=	
CAQUM	CAMASSIA	QUAMASH	MAXIMA	(GOULD) C. L. HITCHC.	=	
CAQUQ	CAMASSIA	QUAMASH	QUAMASH	(PURSH) GREENE	=COMMON CAMAS	
CASU	CAMASSIA	SUKSDORFII		GREENM.	=SUKSDORF CAMAS	1
CAMEL	CAMELINA			CRANTZ	=FALSEFLAX	
CAMI 3	CAMELINA	MICROCARPA		ANDRZ.	=LITTLEPOD FALSEFLAX	
CASA 3	CAMELINA	SATIVA		(L.) CRANTZ	=	
CAMPA	CAMPANULA			L.	=BELLFLOWER; HAREBELL	
CALA 5	CAMPANULA	LASIOCARPA		CHAM.	=	
CAME 3	CAMPANULA	MEDIUM		L.	=	
CAPE 6	CAMPANULA	PERSICIFOLIA		L.	=	
CAPE 2	CAMPANULA	PETIOLATA		A. DC.	=AMERICAN HAREBELL	1
CAPI	CAMPANULA	PIPERI		HOWELL	=PIPER BELLFLOWER	
CAPR 3	CAMPANULA	PRENANTHOIDES		DUR.	=CALIFORNIA BELLFLOWER	

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CARO 3	CAMPANULA	ROTUNDIFOLIA		L.	=BLUEBELL	
CASC	CAMPANULA	SCABRELLA		ENGELM.	=ROUGH BELLFLOWER	
CASC 2	CAMPANULA	SCOULERI		HOOK. EX A. DC.	=	
CANBY	CANBYA			PARRY	=CANBYA	
CAAU 2	CANBYA	AUREA		WATS.	=	
CAPSE	CAPSELLA			MEDIK.	=SHEPHERDS PURSE	
CABU	CAPSELLA	BURSA-PASTORIS		(L.) MEDIK.	=SHEPHERDS PURSE	
CARDA	CARDAMINE			L.	=BITTERCRESS; TOOTHWORT	
CAAN 2	CARDAMINE	ANGULATA		HOOK.	=ANGLED BITTERCRESS	
CABE 2	CARDAMINE	BELLIDIFOLIA		L.	=	
CABR 2	CARDAMINE	BREWERI		WATS.	=	
CACAC	CARDAMINE	CALIFORNICA	CARDIOPHYLLA	(GREENE) DETL.	=	
CACO 2	CARDAMINE	CORDIFOLIA		GRAY	=	
CAHI	CARDAMINE	HIRSUTA		L.	=PENNSYLVANIA BITTERCRESS	
CAIN 6	CARDAMINE	INTEGRIFOLIA		(NUTT.) GREENE	=	
CAINS	CARDAMINE	INTEGRIFOLIA	SINUATA	(GREENE) C. L. HITCHC.	=MILK-MAIDS; TOOTHWORT	
CALY 2	CARDAMINE	LYALLII		WATS.	=	1
CAOC	CARDAMINE	OCCIDENTALIS		(WATS.) HOW.	=	
CAOL	CARDAMINE	OLIGOSPERMA		NUTT.	=	
CAPA 6	CARDAMINE	PATTERSONII		HENDERS.	=	
CAPE 3	CARDAMINE	PENDULIFLORA		SCHULTZ	=	
CAPE 4	CARDAMINE	PENSYLVANICA		MUHL.	=	
CAPU 2	CARDAMINE	PULCHERRIMA		GREENE	=	
CAPUT	CARDAMINE	PULCHERRIMA	TENELLA	(PURSH) C. L. HITCHC.	=	
CARDA2	CARDARIA			DESV.	=WHITETOP; HOARYCRESS	
CADR 2	CARDARIA	DRABA		(L.) DESV.	=	

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CAPU 3	CARDARIA	PUBESCENS		(MEY.) JARM. =	
CASTI	CASTILLEJA			MUTIS EX L. =PAINTBRUSH; PAINTEDCUP	
CAAN	CASTILLEJA	ANGUSTIFOLIA		(NUTT.) G. DON =NORTHWESTERN PAINTBRUSH	
CAAP 2	CASTILLEJA	APPLEGATEI		FERN. =	
CAAR	CASTILLEJA	ARACHNOIDEA		GREENM. =	
CACE	CASTILLEJA	CERVINA		GREENM. =	
CACH 2	CASTILLEJA	CHROMOSA		A. NELS. =DESERT PAINTBRUSH	
CACH 3	CASTILLEJA	CHRYSANTHA		GREENM. =	
CACO 4	CASTILLEJA	COVILLEANA		HENDERSON =	
CACR	CASTILLEJA	CRISPULA		PIPER =	1
CACR 4	CASTILLEJA	CRISTA-GALLI		RYDB. =	
CACR 6	CASTILLEJA	CRYPTANTHA		PENNELL & JONES =	
CACU 3	CASTILLEJA	CUSICKII		GREENM. =	
CAEL 2	CASTILLEJA	ELMERI		FERN. =	
CAEX 2	CASTILLEJA	EXILIS		A. NELS. =	
CAFL 2	CASTILLEJA	FLAVA		WATS. =	
CAFR 2	CASTILLEJA	FRATERNA		GREENM. =	
CAGL	CASTILLEJA	GLANDULIFERA		PENNELL =	
CAGR	CASTILLEJA	GRACILLIMA		RYDB. =	
CAHI 2	CASTILLEJA	HISPIDA		BENTH. =HARSH PAINTBRUSH	
CAHIA	CASTILLEJA	HISPIDA	ACUTA	(PENNELL) OWNBEY =	
CAHIH	CASTILLEJA	HISPIDA	HISPIDA	BENTH. =	
CAIN 7	CASTILLEJA	INVERTA		PENNELL & OWNBEY =	
CALA 2	CASTILLEJA	LAUTA		A. NELS. =YELLOWSTONE PAINTBRUSH	1
CALE 7	CASTILLEJA	LEVISECTA		GREENM. =	
CALI 2	CASTILLEJA	LINARIAEFOLIA		BENTH. =WYOMING PAINTBRUSH	

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CALO 2	CASTILLEJA	LONGISPICA		A. NELS. =	
CALU 2	CASTILLEJA	LUTEA		HELL. =HAIRY PAINTBRUSH	1
CALU 3	CASTILLEJA	LUTESCENS		(GREENM.) RYDB. =	
CAMI 2	CASTILLEJA	MINIATA		DOUGL. EX HOOK. =SCARLET PAINTBRUSH	
CAOC 2	CASTILLEJA	OCCIDENTALIS		TORR. =WESTERN PAINTBRUSH	
CAOR 2	CASTILLEJA	OREOPOLA		GREENM. =	1
CAOR 3	CASTILLEJA	ORESBIA		GREENM. =	
CAOW	CASTILLEJA	OWNBEYANA		PENNELL =	
CAPA 5	CASTILLEJA	PALLESCENS		(GRAY) GREENM. =PALLID PAINTBRUSH	
CAPA 3	CASTILLEJA	PARVIFLORA		BONG. =SMALLFLOWER PAINTBRUSH	
CAPAA	CASTILLEJA	PARVIFLORA	ALBIDA	(PENNELL) OWNBEY =	
CAPAO2	CASTILLEJA	PARVIFLORA	OLYMPICA	(G. N. JONES) OWNBEY =	
CAPAO	CASTILLEJA	PARVIFLORA	OREPOLA	(GREENM.) OWNBEY =MAGENTA PAINTBRUSH	
CAPI 2	CASTILLEJA	PILOSA		(WATS.) RYDB. =WHITE PAINTBRUSH	1
CAPI 3	CASTILLEJA	PINETORUM		FERN. =PINE PAINTBRUSH	1
CAPR 4	CASTILLEJA	PRUINOSA		FERN. =	
CARH	CASTILLEJA	RHEXIFOLIA		RYDB. =SPLITLEAF PAINTBRUSH	
CARU 3	CASTILLEJA	RUBIDA		PIPER =	
CARU 4	CASTILLEJA	RUPICOLA		PIPER =	
CASU 3	CASTILLEJA	SUKSDORFII		GRAY =	
CASU 8	CASTILLEJA	SULPHUREA		RYDB. =	
CATH	CASTILLEJA	THOMPSONII		PENNELL =	
CAXA	CASTILLEJA	XANTHOTRICHA		PENNELL =	
CAULA	CAULANTHUS			WATS. =WILD CABBAGE; CAULANTHUS	
CACR 2	CAULANTHUS	CRASSICAULIS		(TORR.) WATS. =	
CAPI 4	CAULANTHUS	PILOSUS		WATS. =	

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CODA	CDASYNOTUS	DAUBENMIREI		JOHNST. =	
CENTA	CENTAUREA			L. =CENTAUREA; STAR-THISTLE	
CECA	CENTAUREA	CALCITRAPA		L. =	
CECY	CENTAUREA	CYANUS		L. =	
CEDI	CENTAUREA	DIFFUSA		LAM. =	
CEME	CENTAUREA	MELITENSIS		L. =MALTA CENTAUREA	
CERE	CENTAUREA	REPENS		L. =RUSSIAN CENTAUREA	
CESO	CENTAUREA	SOLSTITIALIS		L. =YELLOW CENTAUREA	
CEMO 2	CENTAURIA	MONTANA		L. =	
CENTA2	CENTAURIUM			CASS. =CENTAURIUM; CENTAURY	
CEEX	CENTAURIUM	EXALTATUM		(GRISEB.) WIGHT EX PIPER =	
CEMU	CENTAURIUM	MUHLENBERGII		(GRISEB.) WIGHT EX PIPER =	
CEUM	CENTAURIUM	UMBELLATUM		GILIB. =	
CENTU	CENTUNCULUS			L. =CHAFFWEED	
CEMI	CENTUNCULUS	MINIMUS		L. =	
CEAU	CEPHALANTHERA	AUSTINAE		GRAY =AUSTIN PHANTOMCRCHIC	2
CERAS	CERASTIUM			L. =CERASTIUM; CHICKWEED	
CEAR	CERASTIUM	ARVENSE		L. =STARRY CERASTIUM	
CEBE	CERASTIUM	BEERINGIANUM		CHAM. & SCHLECHT. =	
CEDU	CERASTIUM	DUBIUM		(BAST.) O. SCHWARTZ. =	
CENU	CERASTIUM	NUTANS		RAF. =	
CESE	CERASTIUM	SEMIDECANDRUM		L. =	
CEST	CERASTIUM	STRICTUM		L. =CCMMON CERASTIUM	1
CEVI	CERASTIUM	VISCOSUM		L. =STICKY CERASTIUM	
CEVU	CERASTIUM	VULGATUM		L. =BIG CERASTIUM	
CEDE	CERATOPHYLLUM	DEMERSUM		L. =HCRNWORT	

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CHAEN	CHAENACTIS			DC.	=CHAENACTIS	
CHAL 2	CHAENACTIS	ALPINA		(GRAY) JONES	=	
CHCU	CHAENACTIS	CUSICKII		GRAY	=	
CHDO	CHAENACTIS	DOUGLASII		(HOOK.) H. & A.	=DOUGLAS CHAENACTIS	
CHDOD	CHAENACTIS	DOUGLASII	DOUGLASII	(HOOK.)H. & A.	=DOUGLAS CHAENACTIS	
CHDOG	CHAENACTIS	DOUGLASII	GLANDULOSA	CRONQ.	=	
CHEV	CHAENACTIS	EVERMANNII		GREENE	=	
CHRA	CHAENACTIS	RAMOSA		STOCKWELL	=	
CHTH	CHAENACTIS	THOMPSONII		CONQUIST	=	
CHAMA	CHAMAESARACHA			GRAY	=CHAMAESARACHA	
CHNA 2	CHAMAESARACHA	NANA		GRAY	=	
CHEIL	CHEILANTHES			S. W.	=LIPFERN	
CHFE	CHEILANTHES	FEEI		MOORE	=	
CHGR	CHEILANTHES	GRACILLIMA		D. C. EAT.	=LACE LIPFERN	
CHLA 2	CHEILANTHES	LANOSA		(MICHX.) D. C. EAT.	=	
CHSI	CHEILANTHES	SILIQUOSA		MAXON	=PODFERN	2
CHENO	CHENOPODIUM			L.	=GOOSEFOOT; LAMB S QUARTERS	
CHAL	CHENOPODIUM	ALBUM		L.	=LAMBSQUARTERS GOOSEFOOT	
CHBO	CHENOPODIUM	BOTRYS		L.	=JERUSALEMOAK GOOSEFOOT	
CHCA	CHENOPODIUM	CAPITATUM		(L.) ASCH.	=	
CHCH	CHENOPODIUM	CHENOPODIOIDES		(L.) AELLEN	=	
CHFO	CHENOPODIUM	FOLIOSUM		(MOENCH) ASCH.	=	
CHFR	CHENOPODIUM	FREMONTII		WATS.	=	
CHGL 2	CHENOPODIUM	GLAUCUM		L.	=	
CHHY	CHENOPODIUM	HYBRIDUM		L.	=MAPLELEAF GOOSEFOOT	
CHLE	CHENOPODIUM	LEPTOPHYLLUM		(MOQ.) WATS.	=SLIMLEAF GOOSEFOOT	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
CHMU	CHENOPODIUM	MURALE		L.	=	
CHRU	CHENOPODIUM	RUBRUM		L.	=	
CHION	CHIONOPHILA			BENTH.	=SNOWLOVER; CHIONOPHILA	
CHTW	CHIONOPHILA	TWEEDYI		(CANBY & ROSE) HENDERSON	=	
CHLOR2	CHLOROCRAMBE			RYDB.	=CHLOROCRAMBE	
CHHA	CHLOROCRAMBE	HASTATA		(WATS.) RYDB.	=	
CHLOR	CHLOROGALUM			KUNTH.	=SOAPPLANT	
CHPO	CHLOROGALUM	POMERIDIANUM		(DC.) KUNTH.	=AMOLE SOAPPLANT	
CHOND	CHONDRILLA			L.	=SKELTON-WEED; CHONDRILLA	
CHJU	CHONDRILLA	JUNCEA		L.	=	
CHORI	CHORISPORA			R. BR.	=CHORISPORA; BLUE MUSTARD	
CHTE	CHORISPORA	TENELLA		(PALL.) DC.	=CHORISPORA	
CHORI2	CHORIZANTHE			R. BR.	=CORIZANTHE; SPINE-FLOWER	
CHBR	CHORIZANTHE	BREVICORNU		TORR.	=	
CHWA	CHORIZANTHE	WATSONII		T. & G.	=	
CHRYS	CHRYSANTHEMUM			L.	=CHRYSANTHEMUM	
CHLE 2	CHRYSANTHEMUM	LEUCANTHEMUM		L.	=OXEYEDAISY	
CHLEL	CHRYSANTHEMUM	LEUCANTHEMUM	LEUCANTHEMUM	L.	=OXEYEDAISY	
CHLEP	CHRYSANTHEMUM	LEUCANTHEMUM	PINNATIFIDUM	LEC. & LAM.	=FIELD OXEYEDAISY	
CHPA	CHRYSANTHEMUM	PARTHENIUM		(L.) BERNH.	=	
CHRYS2	CHRYSOPSIS			ELL.	=GOLDASTER	
CHOR	CHRYSOPSIS	OREGANA		(NUTT.) GRAY	=OREGON GOLDASTER	
CHVI 2	CHRYSOPSIS	VILLOSA		(PURSH) NUTT. EX DC.	=HAIRY GOLDASTER	
CHRYS4	CHRYSOSPLENIUM			L.	=GOLDEN-CARPET; GOLDEN-SAXIFRAGE; WATER CARPET	
CHGL	CHRYSOSPLENIUM	GLECHOMAEFOLIUM		NUTT.	=	
CHTE 2	CHRYSOSPLENIUM	TETRANDUM		(LUND) FRIES	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
CHNAG	CHRYSOTHAMNUS	NAUSEOSUS	GLABRATUS	(GRAY) CRONQ. =	
CICHO	CICHORIUM			L. =CHICORY	
CIIN	CICHORIUM	INTYBUS		L. =	
CICUT	CICUTA			L. =WATERHEMLOCK	
CIBU	CICUTA	BULBIFERA		L. =BULBED WATERHEMLOCK	
CIDO	CICUTA	DOUGLASII		(DC.) COULT. & ROSE =WESTERN WATERHEMLOCK	
CIVA	CICUTA	VAGANS		GREENE =	1
CIMIC	CIMICIFUGA			L. =BUGBANE	
CIEL	CIMICIFUGA	ELATA		NUTT. =	
CILA 3	CIMICIFUGA	LACINIATA		WATS. =	
CIRCA	CIRCAEA			L. =CIRCAEA	
CIAL	CIRCAEA	ALPINA		L. =ALPINE CIRCAEA	
CIPA	CIRCAEA	PACIFICA		ASCH. & MAG. =	1
CIRSI	CIRSIUM			ADANS. =THISTLE	
CIAC	CIRSIUM	ACAULESCENS		K.SCHUM. =	1
CIAM	CIRSIUM	AMERICANUM		(GRAY) DANIELS. =	1
CIAR	CIRSIUM	ARVENSE		(L.) SCOP. =CANADA THISTLE	
CIBR	CIRSIUM	BREVIFOLIUM		NUTT. =	
CIBR 2	CIRSIUM	BREVISTYLUM		CRONQ. =	
CICA	CIRSIUM	CANESCENS		NUTT. =	
CICA 2	CIRSIUM	CANOVIRENS		(RYDB.) PETR. =	
CICE	CIRSIUM	CENTAUREAE		(RYDB.) K.SCHUM. =	
CIDRA	CIRSIUM	DRUMMONDII	ACAULESCENS	MACBR. =	1
CIED	CIRSIUM	EDULE		NUTT. =INDIAN THISTLE	
CIFO	CIRSIUM	FOLIOSUM		(HOOK.) DC. =ELK THISTLE	
CIHO	CIRSIUM	HOOKERIANUM		NUTT. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
CILA	CIRSIUM	LANCEOLATUM		HILL	1
CIMA	CIRSIUM	MAGNIFICUM		(A. NELS.) PETR.	
CIOCC	CIRSIUM	OCCIDENTALE	CANDIDISSIMUM	HALL =SNOWWOOL WESTERN THISTLE	1
CIPA 2	CIRSIUM	PASTORIS		J. T. HOWELL	
CIPO	CIRSIUM	POLYPHYLLUM		(RYDB.) PETR.	1
CIRE	CIRSIUM	REMOTIFOLIUM		(HOOK.) DC.	
CISU	CIRSIUM	SUBNIVEUM		RYDB.	
CITW	CIRSIUM	TWEEDYI		RYDB.	
CIUN	CIRSIUM	UNDULATUM		(NUTT.) SPRENG. =WAVYLEAF THISTLE	
CIUT	CIRSIUM	UTAHENSE		PETR.	
CIVU	CIRSIUM	VULGARE		(SAVI) AIRY-SHAW =BULL THISTLE	
CLARK	CLARKIA			PURSH =CLARKIA; GODETIA	
CLAM	CLARKIA	AMOENA		(LEHM.) NELS. & MACBR.	
CLAMA	CLARKIA	AMOENA	AMOENA	(LEHM.) NELS. & MACBR.	
CLAMC	CLARKIA	AMOENA	CAURINA	(ABRAMS) C. L. HITCHC.	
CLAML	CLARKIA	AMOENA	LINDLEYI	(DOUGL.) C. L. HITCHC.	
CLAMP	CLARKIA	AMOENA	PACIFICA	(PECK) C. L. HITCHC.	
CLGR	CLARKIA	GRACILIS		(PIPER) NELS. & MACBR.	
CLPU	CLARKIA	PULCHELLA		PURSH =ELKHORNS CLARKIA	
CLQU	CLARKIA	QUADRIVULNERA		(DOUGL.) NELS. & MACBR.	
CLRH	CLARKIA	RHOMBOIDEA		DOUGL. EX HOOK.	
CLVI 2	CLARKIA	VIMINEA		(DOUGL.) NELS. & MACBR.	
CLAYT	CLAYTONIA			L. =SPRINGBEAUTY	
CLAR	CLAYTONIA	ARENICOLA		HENDERS.	2
CLAS	CLAYTONIA	ASARIFOLIA		GRAY	2
CLBE	CLAYTONIA	BELLIDIFOLIA		RYDB.	1

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CLCH	CLAYTONIA	CHAMISSOI		LEDEB. EX SPRENG. =WATER SPRINGBEAUTY	2
CLCH 2	CLAYTONIA	CHRYSANTHA		GREENE =	1
CLCO 2	CLAYTONIA	CORDIFOLIA		WATS. =	2
CLDI	CLAYTONIA	DICHOTOMA		NUTT. =	2
CLFL	CLAYTONIA	FLAVA		A. NELS. =	1
CLLA	CLAYTONIA	LANCEOLATA		PURSH =LANCELEAF SPRINGBEAUTY	
CLLAC	CLAYTONIA	LANCEOLATA	CHRYSANTHA	(GREENE) C. L. HITCHC. =	
CLLAF	CLAYTONIA	LANCEOLATA	FLAVA	(A. NELS.) C. L. HITCHC. =	
CLMEB	CLAYTONIA	MEGARHIZA	BELLIDIFOLIA	(RYDB.) C. L. HITCHC. =	
CLMEN	CLAYTONIA	MEGARHIZA	NIVALIS	(ENGLISH) C. L. HITCHC. =	
CLME	CLAYTONIA	MEGARRHIZA		(GRAY) PARRY EX WATS. =ALPINE SPRINGBEAUTY	
CLNI	CLAYTONIA	NIVALIS		ENGLISH =	1
CLPAD	CLAYTONIA	PARVIFLORA	DEPRESSA	GRAY =	
CLPA	CLAYTONIA	PARVIFOLIA		MOQ. =	2
CLPE	CLAYTONIA	PERFOLIATA		DONN =	2
CLRU	CLAYTONIA	RUBRA		TIDESTR. =	2
CLSI	CLAYTONIA	SIBIRICA		L. =	2
CLSP	CLAYTONIA	SPATHULATA		DOUGL. =	2
CLUM	CLAYTONIA	UMBELLATA		WATS. =UMBELLATE SPRINGBEAUTY	
CLEMA2	CLEMATIS			L. =	
CLCOC	CLEMATIS	COLUMBIANA	COLUMBIANA	(NUTT.) T. & G. =	
CLCOD	CLEMATIS	COLUMBIANA	DISSECTA	C. L. HITCHC. =	
CLHI	CLEMATIS	HIRSUTISSIMA		PURSH =DOUGLAS CLEMATIS	
CLLI	CLEMATIS	LIGUSTICIFOLIA		NUTT. =WESTERN VIRGINSBOWER	
CLEOM	CLEOME			L. =SPIDERFLOWER	
CLLU	CLEOME	LUTEA		HOOK. =YELLOW SPIDERFLOWER	

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CLPL	CLEOME	PLATYCARPA		TORR. =	
CLSE	CLEOME	SERRULATA		PURSH =	
CLEOM2	CLEOMELLA			DC. =CLEOMELLA	
CLMA	CLEOMELLA	MACBRIDEANA		PAYS. =	
CLOO	CLEOMELLA	OOCARPA		GRAY =	1
CLPL 2	CLEOMELLA	PLOCASPERMA		WATS. =	
CLINT	CLINTONIA			DOUGL. =BEADLILLY	
CLAN	CLINTONIA	ANDREWSIANA		TORR. =RED BEAD LILY	
CLUN	CLINTONIA	UNIFLORA		(SCHULT.) KUNTH =QUEENCUP BEADLILY	
CNNE	CNAENACTIS	NEVII		GRAY =	
COLDE	COLDENIA			L. =COLDENIA	
CONU 2	COLDENIA	NUTTALLII		HOOK. =NUTTALL COLDENIA	
COLLI	COLLINSIA			NUTT. =COLLINSIA	
COFL	COLLINSIA	FLORIBUNDA		GREENE =	2
COGR	COLLINSIA	GRANDIFLORA		LINDL. =BLUETIPS COLLINSIA	
COLI	COLLINSIA	LINEARIS		GRAY =	
COPA	COLLINSIA	PARVIFLORA		LINDL. =LITTLEFLOWER COLLINSIA	
COPU	COLLINSIA	PUSILLA		HOW. =	1
CORA 2	COLLINSIA	RATTANII		GRAY =	
COSP	COLLINSIA	SPARSIFLORA		FISCH. & MEY. =	
COTE 3	COLLINSIA	TENELLA		BENTH. =	2
COLLO	COLLOMIA			=COLLOMIA	
COAR	COLLOMIA	ARISTELLA		RYDB. =	1
CODE	COLLOMIA	DEBILIS		(WATS.) GREENE =	
COGR 2	COLLOMIA	GRANDIFLORA		DOUGL. EX LINDL. =	
COHE	COLLOMIA	HETEROPHYLLA		HOOK. =	

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COLI 2	COLLOMIA	LINEARIS		NUTT. =	
COMA	COLLOMIA	MAZAMA		COV. =SPOTTED CORALROOT	
COTE	COLLOMIA	TENELLA		GRAY =	
COTI	COLLOMIA	TINCTORIA		KELL. =	
COMAN	COMANDRA			NUTT. =COMANDRA	
COCA 5	COMANDRA	CALIFORNICA		EASTW. =	1
COLI 3	COMANDRA	LIVIDA		RICHARDS. =	
COPA 2	COMANDRA	PALLIDA		DC. =PALE COMANDRA	1
COUM	COMANDRA	UMBELLATA		(L.) NUTT. =COMMON COMANDRA	
COUMC	COMANDRA	UMBELLATA	CALIFORNICA	(EASTW.) C. L. HITCHC. =	
COUMU	COMANDRA	UMBELLATA	UMBELLATA	(L.)NUTT. =COMMON COMANDRA	
CONIO	CONIOSELINUM			FISCH. =HEMLOCKPARSLEY	
COPA 3	CONIOSELINUM	PACIFICUM		(WATS.) COULT. & ROSE =	
COSC 2	CONIOSELINUM	SCOPULORUM		COULT. & ROSE =ROCKYMOUNTAIN HEMLOCKPARSLEY	
CONIU	CONIUM			L. =POISON HEMLOCK	
COMA 2	CONIUM	MACULATUM		L. =POISON HEMLOCK	
CONRI	CONRINGIA			LINK =HARESEAR	
COOR	CONRINGIA	ORIENTALIS		(L.) BUMORT. =TREACLE HARESEAR	
CONVO	CONVOLVULUS			L. =MORNING-GLORY; BINDWEED	
COAR 2	CONVOLVULUS	ARVENSIS		L. =FIELD BINDWEED	
COCA 3	CONVOLVULUS	CALIFORNICUS		CHOISY. =	1
CONY	CONVOLVULUS	NYCTAGINEUS		GREENE =	
COPO	CONVOLVULUS	POLYMORPHUS		GREENE =VARIABLE MORNING-GLORY	
COSE	CONVOLVULUS	SEPIUM		L. =	
COSO	CONVOLVULUS	SOLDANELLA		L. =SEASHORE MORNING-GLORY	
COSU	CONVOLVULUS	SUBACAULIS		(H. & A.) GREENE =	

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CONYZ	CONYZA			L. =CONYZA; HORSEWEED	
COCA 2	CONYZA	CANADENSIS		(L.) CRONQ. =HORSEWEED	
COCAC2	CONYZA	CANADENSIS	CANADENSIS	(L.) CRONQ. =HORSEWEED	
COCAG	CONYZA	CANADENSIS	GLABRATA	(GRAY) CRONQ. =	
COPTI	COPTIS			SALISB. =GOLDTHREAD	
COAS	COPTIS	ASPLENIFOLIA		SALISB. =	
COLA	COPTIS	LACINIATA		GRAY =CUTLEAF GOLDTHREAD	
COOC 2	COPTIS	OCCIDENTALIS		(NUTT.) T. & G. =	
CORAL	CORALLORHIZA			R. BR. =CORALROOT	
COMA 3	CORALLORHIZA	MACULATA		RAF. =	
COME	CORALLORHIZA	MERTENSIANA		BONG. =PACIFIC CORALROOT	
COST 2	CORALLORHIZA	STRIATA		LINDL. =HOODED CORALROOT	
COTR	CORALLORHIZA	TRIFIDA		CHAT. =	
COWI	CORALLORHIZA	WISTERIANA		CONRAD =	
CORDY	CORDYLANTHUS			BLUME =BIRDBEAK	
COCA 4	CORDYLANTHUS	CAPITATUS		NUTT. EX BENTH. =	
COPIT	CORDYLANTHUS	PILOSUS	TENUIS	JEPS. =	1
CORA	CORDYLANTHUS	RAMOSUS		NUTT. EX BENTH. =BUSHY BIRDBEAK	
COTE 2	CORDYLANTHUS	TENUIS		GRAY =	
COREO	COREOPSIS			L. =COREOPSIS; TICKSEED	
COAT	COREOPSIS	ATKINSONIANA		DOUGL. =	
CORIS	CORISPERMUM			L. =BUGSEED	
COHY	CORISPERMUM	HYSSOPIFOLIUM		L. =	
CONI	CORISPERMUM	NITIDUM		KIT. =	
COCA	CORNUS	CANADENSIS		L. =BUNCHBERRY DOGWOOD	
CORON	CORONILLA			L. =CORONILLA; CROWN VETCH	

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COVA	CORONILLA	VARIA		L. =	
CORYD	CORYDALIS			VENT. =CORYDALIS	
COAQ	CORYDALIS	AQUAE-GELIDAE		PECK & WILS. =	
COAUO	CORYDALIS	AUREA	OCCIDENTALIS	ENGELM. =GOLDEN CORYDALIS	
COCAC	CORYDALIS	CASEANA	CUSICKII	(WATS.) C. L. HITCHC. =	
COCAH	CORYDALIS	CASEANA	HASTATA	(RYDB.) C. L. HITCHC. =	
COCU	CORYDALIS	CUSICKII		WATS. =	1
COLU	CORYDALIS	LUTEA		DC. =	
COSC	CORYDALIS	SCOULERI		HOOK. =SCOULER CORYDALIS	
CORYP	CORYPHANTHA			(ENGELM.) =CORYPHANTHA; CACTUS	
COMI	CORYPHANTHA	MISSOURIENSIS		(SWEET) BRITT. & ROSE =	
COVI	CORYPHANTHA	VIVIPARA		(NUTT.) BRITT. & BROWN =	
COTUL	COTULA			L. =BRASSBUTTONS	
COCO	COTULA	CORONOPIFOLIA		L. =BIRD BRASSBUTTONS	
CREPI	CREPIS			L. =HAWKSBEARD	
CRAC	CREPIS	ACUMINATA		NUTT. =TAPERTIP HAWKSBEARD	
CRAT	CREPIS	ATRABARBA		HELLER =SLENDER HAWKSBEARD	
CRBA	CREPIS	BAKERI		GREENE =	
CRBA 2	CREPIS	BARBIGERA		LEIB. EX COV. =	
CRCA	CREPIS	CAPILLARIS		(L.) WALLR. =SMOOTH HAWKSBEARD	
CRIN	CREPIS	INTERMEDIA		GRAY =GRAY HAWKSBEARD	
CRMO 3	CREPIS	MODOCENSIS		GREENE =	
CRMOR	CREPIS	MODOCENSIS	ROSTRATA	(COVILLE) BABC. & STEBB. =	
CRMO	CREPIS	MONTICOLA		COV. =SISKIYOU HAWKSBEARD	
CRNA	CREPIS	NANA		RICH. =	
CRNI	CREPIS	NICAEENSIS		BALB. EX PERS. =	

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CROC	CREPIS	OCCIDENTALIS		NUTT. =WESTERN HAWKSBEARD	
CROCC	CREPIS	OCCIDENTALIS	COSTATA	(GRAY) BABC. & STEBB. =	
CRRU	CREPIS	RUNCINATA		(JAMES) T. & G. =DANDELION HAWKSBEARD	
CRRUG	CREPIS	RUNCINATA	GLAUCA	(NUTT.) BABC. & STEBB. =	
CRRUH	CREPIS	RUNCINATA	HISIDULOSA	(HOWELL) BABC. & STEBB. =	
CRSE	CREPIS	SETOSA		HALL =	
CROCI	CROCIDIUM			HOOK. =CROCIDIUM; SPRING-GOLD	
CRMU	CROCIDIUM	MULTICAULE		HOOK. =	
CRNU	CRYPTANATHA	NUBIGENA		(GREENE) PAYS. =	
CRYPT2	CRYPTANTHA			LEHM. =CRYPTANTHA	
CRAF	CRYPTANTHA	AFFINIS		(GRAY) GREENE =	
CRAM	CRYPTANTHA	AMBIGUA		(GRAY) GREENE =	
CRCE	CRYPTANTHA	CELOSIOIDES		(EASTW.) PAYS. =	
CRCI	CRYPTANTHA	CIRCUMSCISSA		(H. & A.) JOHNST. =	
CREC	CRYPTANTHA	ECHINELLA		GREENE =	
CRFE	CRYPTANTHA	FENDLERI		(GRAY) GREENE =	
CRFL	CRYPTANTHA	FLACCIDA		(DOUGL.) GREENE =WEAKSTEMMED CRYPTANTHA	
CRFL 2	CRYPTANTHA	FLAVOCULATA		(NELS.) PAYS. =	
CRIN 2	CRYPTANTHA	INTERMEDIA		(GRAY) GREENE =	
CRIN 3	CRYPTANTHA	INTERRUPTA		(GREENE) PAYS. =	
CRKE	CRYPTANTHA	KELSEYANA		GREENE =	
CRLE	CRYPTANTHA	LEUCOPHAEA		(DOUGL.) PAYS. =	
CRMU 2	CRYPTANTHA	MURICULATA		GREENE =GOLDSTAR	1
CRPR	CRYPTANTH	PROPRIA		(NELS. & MACBR.) PAYS. =	
CRPT	CRYPTANTHA	PTEROCARYA		(TORR.) GREENE =	
CRRO	CRYPTANTHA	ROSTELLATA		GREENE =	

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CRSA	CRYPTANTHA	SALMONENSIS		(NELS. & MACBR.) PAYS.	=	
CRSC	CRYPTANTHA	SCOPARIA		A. NELS.	=	
CRSI	CRYPTANTHA	SIMULANS		GREENE	=PINE WOODS CRYPTANTHA	
CRTO	CRYPTANTHA	TORREYANA		(GRAY) GREENE	=TORREY CRYPTANTHA	
CRTH	CRYPTANTHE	THOMPSONII		JOHNST.	=	
CRYPT3	CRYPTOGRAMMA			R. BR.	=ROCKBRAKE	
CRAC 2	CRYPTOGRAMMA	ACROSTICHOIDES		R. BR.	=AMERICAN ROCKBRAKE	
CRCR	CRYPTOGRAMMA	CRISPA		(L.) R. BR. EX HOOK.	=	
CRDE	CRYPTOGRAMMA	DENSA		(BRACKENR.) DIELS IN E. & P.	=	
CRST	CRYPTOGRAMMA	STELLERI		(S. G. GMEL.) PRANTL	=	
CUSCU	CUSCUTA			L.	=DODDER	
CUAP	CUSCUTA	APPROXIMATA		BABINGTON	=	
CUCA	CUSCUTA	CALIFORNICA		CHOISY	=	
CUCE	CUSCUTA	CEPHALANTHI		ENGELM.	=	
CUDE	CUSCUTA	DENTICULATA		ENGELM.	=	
CUEP	CUSCUTA	EPITHYMUM		MURR.	=	
CUOC	CUSCUTA	OCCIDENTALIS		MILLSPAUGH	=	
CUPE	CUSCUTA	PENTAGONA		ENGELM.	=	
CUSA	CUSCUTA	SALINA		ENGELM.	=	
CUSU	CUSCUTA	SUBINCLUSA		DUR. & HILG.	=	
CUSU 2	CUSCUTA	SUKSDORFII		YUNCKER	=	
CYMOP	CYMOPTERUS			RAF.	=CYMOPTERUS	
CYAC	CYMOPTERUS	ACAULIS		(PURSH) RAF.	=	
CYBI	CYMOPTERUS	BIPINNATUS		WATS.	=	
CYGL	CYMOPTERUS	GLAUCUS		NUTT.	=	
CYHE	CYMOPTERUS	HENDERSONII		(COULT. & ROSE) CRONQ.	=	

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CYNI	CYMOPTERUS	NIVALIS		WATS. =	
CYPE	CYMOPTERUS	PETRAEUS		M. E. JONES =	
CYTEF	CYMOPTERUS	TEREBINTHINUS	FOENICULACEUS	(T. & G.) CRONQ. =	
CYTET	CYMOPTERUS	TEREBINTHINUS	TEREBINTHINUS	(HOOK.) T. & G. =	
CYWA	CYMOPTERUS	WATSONI		(C.&R.) M.E.JONES =	
CYNOG	CYNOGLOSSUM			L. =HOUNDSTONGUE	
CYGR	CYNOGLOSSUM	GRANDE		DOUGL. EX LEHM. =PACIFIC HOUNDSTONGUE	
CYOC	CYNOGLOSSUM	OCCIDENTALE		GRAY =WESTERN HOUNDSTONGUE	
CYOF	CYNOGLOSSUM	OFFICINALE		L. =COMMON HOUNDSTONGUE	
CYPRI	CYPRIPEDIUM			L. =LADYS-SLIPPER	
CYCAP	CYPRIPEDIUM	CALCEOLUS	PARVIFLORUM	(SALISB.) FERN. =	
CYCA	CYPRIPEDIUM	CALIFORNICUM		GRAY =	
CYFA	CYPRIPEDIUM	FASCICULATUM		KELL. EX WATS. =	
CYMO	CYPRIPEDIUM	MONTANUM		DOUGL. EX LINDL. =	
CYPA	CYPRIPEDIUM	PARVIFLORUM		SALISB. =	1
CYSTO	CYSTOPTERIS			BERNH. =BLADDERFERN	
CYFR	CYSTOPTERIS	FRAGILIS		(L.) BERNH. =BRITTLE BLADDERFERN	
CYMO 2	CYSTOPTERIS	MONTANA		(LAM.) BERNH. =	
DAMAS	DAMASONIUM			MILL. =DAMASONIUM	
DACA 2	DAMASONIUM	CALIFORNICUM		TORR. =CALIFORNIA DAMASONIUM	2
DARLI	DARLINGTONIA			TORR. =CALIFORNIA PITCHER-PLANT	
DACA 3	DARLINGTONIA	CALIFORNICA		TORR. =CALIFORNIA PITCHER-PLANT	
DASYN	DASYNOTUS			JOHNST. =DASYNOTUS	
DATUR	DATURA			L. =DATURA; JIMSON-WEED	
DAST	DATURA	STRAMONIUM		L. =	
DAUCU	DAUCUS			L. =CARROT	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
DACA 4	DAUCUS	CAROTA		L. =QUEEN ANNES LACE	
DACA 5	DAUCUS	CAROTA		L. =WILD CARROT	
DAPU	DAUCUS	PUSILLUS		MICHX. =	
DELPH	DELPHINIUM			L. =LARKSPUR	
DEAN	DELPHINIUM	ANDERSONII		GRAY =ANDERSON LARKSPUR	
DEBA	DELPHINIUM	BARBEYI		HUTH. =BARBEY LARKSPUR	
DEBI	DELPHINIUM	BICOLOR		NUTT. =LITTLE LARKSPUR	
DEBU	DELPHINIUM	BURKEI		GREENE =	
DECO	DELPHINIUM	COLUMBIANUM		GREENE =COLUMEIA LARKSFUR	
DECY	DELPHINIUM	CYANOREIOS		PIPER =	
DEDE	DELPHINIUM	DEPAUPERATUM		NUTT. =SLIM LARKSPUR	
DEDI	DELPHINIUM	DISTICHUM		GEYER. =TWOSPIKE LARKSPLR	
DEGL 2	DELPHINIUM	GLAREOSUM		GREENE =	
DEGL 3	DELPHINIUM	GLAUCESCENS		RYDB. =	
DEGL	DELPHINIUM	GLAUCUM		WATS. =	
DEGR	DELPHINIUM	GRACILENTUM		GREENE =SCNNE LARKSPUR	
DELE	DELPHINIUM	LEUCOPHAEUM		GREENE =	
DELI	DELPHINIUM	LINEAPETALUM		EWAN =	1
DEME	DELPHINIUM	MENZIESII		DC. =MENZIES LARKSPUR	
DEMEP	DELPHINIUM	MENZIESII	PYRAMIDALE	(EWAN) C. L. HITCHC. =	
DEMU	DELPHINIUM	MULTIFLORUM		RYDB. =MANYFLOWER LARKSPUR	
DEMU 2	DELPHINIUM	MULTIPLEX		(EWAN) C. L. HITCHC. =	
DENE	DELPHINIUM	NELSONII		GREENE =NELSON LARKSPUR	
DENU	DELPHINIUM	NUDICAULE		T. & G. =ORANGE LARKSPUR	
DENU 3	DELPHINIUM	NUTTALLIANUM		PRITZ. EX WALPERS =	
DENUL2	DELPHINIUM	NUTTALLIANUM	LEVICAULE	C. L. HITCHC. =	

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DENUL	DELPHINIUM	NUTTALLIANUM	LINEAPETALUM	(EWAN) C. L. HITCHC.	=	
DENUP	DELPHINIUM	NUTTALLIANUM	PILOSUM	C. L. HITCHC.	=	
DENU 2	DELPHINIUM	NUTTALLII		GRAY	=	
DEOC	DELPHINIUM	OCCIDENTALE		WATS.	=DUNCECAP LARKSPUR	
DEOR	DELPHINIUM	OREGANUM		HOWELL	=OREGON LARKSPUR	
DEPA	DELPHINIUM	PAVONACEUM		EWAN	=	
DESCG	DELPHINIUM	SCOPULORUM	GLAUCUM	GRAY	=SIERRA LARKSPUR	1
DESI	DELPHINIUM	SIMPLEX		HOOK.	=SIMPLESTEM LARKSPUR	
DEST	DELPHINIUM	STACHYDEUM		(GRAY) TIDES.	=ROCKYMOUNTAIN LARKSPUR	
DETR	DELPHINIUM	TROLLIIFOLIUM		GRAY	=COLUMBIARIVER LARKSPUR	
DEVI	DELPHINIUM	VIRIDESCENS		LEIBERG	=	
DEXA	DELPHINIUM	XANTHOLEUCUM		PIPER	=YELLOWWHITE LARKSPUR	
DENTA	DENTARIA			L.	=TOOTHWORT; BITTERCRESS	
DECA 2	DENTARIA	CARDIOPHYLLA		ROB.	=VACA TOOTHWORT	2
DEGR 2	DENTARIA	GRANDIFLORA		RAF.	=CASCADE TOOTHWORT	1
DETE	DENTARIA	TENELLA		PURSH	=OREGON TOOTHWORT	1
DESCU	DESCURAINIA			WEBB	=TANSYMUSTARD	
DELO	DESCURAINIA	LONGIPEDICELLATA		SCHULZ	=SLIMSTEM TANSYMUSTARD	1
DEPI	DESCURAINIA	PINNATA		(WALT.) BRITT.	=PINNATE TANSYMUSTAR	
DEPIF	DESCURAINIA	PINNATA	FILIPES	(GRAY) PECK	=	
DEPIP	DESCURAINIA	PINNATA	PINNATA	(WALT.) BRITT.	=PINNATE TRANSYMUSTER	
DERI	DESCURAINIA	RICHARDSONII		(SWEET) SCHULTZ.	=	
DERII	DESCURAINIA	RICHARDSONII	INCISA	(ENGELM.) DETL.	=WESTERN TANSYMUSTARD	
DERIV	DESCURAINIA	RICHARDSONII	VISCOSA	(RYDB.) PECK	=	
DESO	DESCURAINIA	SOPHIA		(L.) WEBB.	=FLIXWEED TANSYMUSTARD	
DIANT	DIANTHUS			L.	=PINK	

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DIAR	DIANTHUS	ARMERIA		L.	=DEPTFORD PINK	
DIBA	DIANTHUS	BARBATUS		L.	=	
DIDE	DIANTHUS	DELTOIDES		L.	=	
DICEN	DICENTRA			BERNH.	=BLEEDINGHEART	
DICU	DICENTRA	CUCULLARIA		(L.) BERNH.	=DUTCHMANS BREECHES	
DIFO	DICENTRA	FORMOSA		(ANDR.) WALPERS	=PACIFIC BLEEDINGHEART	
DIUN	DICENTRA	UNIFLORA		KELL.	=	
DIGIT2	DIGITALIS			L.	=FOXGLOVE	
DIPU	DIGITALIS	PURPUREA		L.	=	
DIMER	DIMERESIA			GRAY	=DIMERESIA	
DIHO 2	DIMERESIA	HOWELLII		GRAY	=	
DIPLO	DIPLOTAXIS			DC.	=WALLROCKET; DIPLOTAXIS	
DIMU	DIPLOTAXIS	MURALIS		(L.) DC.	=	
DIPSA	DIPSACUS			L.	=TEASEL	
DISY	DIPSACUS	SYLVESTRIS		HUDS.	=	
DISPO	DISPORUM			SALISB.	=FAIRYBELLS	
DIHO	DISPORUM	HOOKERI		(TORR.) NICHOLSON	=	
DISM	DISPORUM	SMITHII		(HOOK.) PIPER	=SMITHS FAIRYBELLS	
DITR	DISPORUM	TRACHYCARPUM		(WATS.) BENTH. & HOOK.	=WARTBERRY FAIRYBELL	
DODEC	DODECATHEON			L.	=SHOOTINGSTAR	
DOAL	DODECATHEON	ALPINUM		(GRAY) GREENE	=ALPINE SHOOTINGSTAR	
DOCO	DODECATHEON	CONJUGENS		GREENE	=SLIMPOD SHOOTINGSTAR	
DOCU	DODECATHEON	CUSICKII		GREENE	=CUSICK SHOOTINGSTAR	1
DODE	DODECATHEON	DENTATUM		HOOK.	=DENTATE SHOOTINGSTAR	
DOHE	DODECATHEON	HENDERSONI		GRAY	=HENDERSON SHOOTINGSTAR	
DOJE	DODECATHEON	JEFFREYI		VAN HOUTTE	=JEFFREY SHOOTINGSTAR	

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DOPA	DODECATHEON	PAUCIFLORUM		(DURAND) GREENE =DARKTHROAT SHOOTINGSTAR	
DOPAA	DODECATHEON	PAUCIFLORUM	ALASKANUM	(HULTEN) C. L. HITCHC. =	
DOPAC	DODECATHEON	PAUCIFLORUM	CUSICKII	(GREENE) MASON EX ST. JOHN =COLUMBIA STICKY SHOOTING STAR	
DOPAM	DODECATHEON	PAUCIFLORUM	MONANTHUM	GREENE =	
DOPAP	DODECATHEON	PAUCIFLORUM	PAUCIFLORUM	(DURAND) GREENE =	
DOPO	DODECATHEON	POETICUM		HENDERSON =	
DOTE	DODECATHEON	TETRANDRUM		(SUKSD.) EX GREENE =YELLOWRING SHOOTINGSTAR	1
DOUGL	DOUGLASIA			LINDL. =DOUGLASIA	
DODE 2	DOUGLASIA	DENTATA		WATS. =	1
DOLA	DOUGLASIA	LAEVIGATA		GRAY =SMOOTH DOUGLASIA	
DOMO	DOUGLASIA	MONTANA		GRAY =	
DONI	DOUGLASIA	NIVALIS		LINDL. =	
DOWNI	DOWNINGIA			TORR. =DOWNINGIA	
DOEL	DOWNINGIA	ELEGANS		(DOUGL.) TORR. =SHOWY DOWNINGIA	
DOLA 2	DOWNINGIA	LAETA		GREENE =	
DOPU	DOWNINGIA	PULCHELLA		(LINDL.) TORR. =CALIFORNIA DOWNINGIA	
DOWI	DOWNINGIA	WILLAMETTENSIS		PECK =	1
DOYI	DOWNINGIA	YINA		APPLEG. =	
DRABA	DRABA			L. =DRABA; WHITLOW-WART	
DRAR 2	DRABA	ARGYRAEA		RYDB. =	
DRAU 3	DRABA	AUREA		VAHL =	
DRAU	DRABA	AUREOLA		WATS. =LASSEN DRABA	
DRBR	DRABA	BRACHYCARPA		NUTT. EX T. & G. =	
DRCR	DRABA	CRASSIFOLIA		R. GRAH. =	
DRDE	DRABA	DENSIFOLIA		NUTT. =	
DRDO	DRABA	DOUGLASII		GRAY =	

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DRGL	DRABA	GLACIALIS		SENSU AM. AUTHORS NOT ADAMS =GLACIER DRABA	1
DRIN	DRABA	INCERTA		PAYS. =	
DRLA	DRABA	LANCEOLATA		ROYLE =	
DRLE	DRABA	LEMMONII		WATS. =	
DRLO 2	DRABA	LONCHOCARPA		RYDB. =	
DRLU	DRABA	LUTEOLA		GREENE =	
DRMI	DRABA	MICRANTHA		NUTT. =	1
DRNE	DRABA	NEMOROSA		L. =WOODS DRABA	
DRNI	DRABA	NITIDA		GREENE =SHINY DRABA	1
DROL	DRABA	OLIGOSPERMA		HOOK. =	
DROLO	DRABA	OLIGOSPERMA	OLIGOSPERMA	HOOK. =	
DROR	DRABA	OREIBATA		MACBR. & PAYS. =	
DRPA 2	DRABA	PAYSONII		MACBR. =	
DRPE	DRABA	PECTINATA		RYDB. =	1
DRPR	DRABA	PRAEALTA		GREENE =	
DRRE	DRABA	REPTANS		(LAM.) FERN. =	
DRSP	DRABA	SPHAEROCARPA		MACBR. & PAYS. =	
DRST	DRABA	STENOLOBA		LEDEB. =	
DRVE	DRABA	VENTOSA		GRAY =	
DRVE 2	DRABA	VERNA		L. =SPRING DRABA	
DRACO	DRACOCEPHALUM			L. =DRAGONHEAD	
DRNU	DRACOCEPHALUM	NUTTALLII		BRITT. =AMERICAN DRAGONHEAC	
DRPA	DRACOCEPHALUM	PARVIFLORUM		NUTT. =AMERICAN DRAGONHEAC	1
DROSE	DROSERA			L. =SUNDEW	
DRAN	DROSERA	ANGLICA		HUDS. =	
DRLO	DROSERA	LONGIFOLIA		AUTHORS NOT L. =NARROWLEAF SUNDEW	1

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DRRO	DROSERA	ROTUNDIFOLIA		L.	=	
DRYAS	DRYAS			L.	=DRYAD	
DRDR	DRYAS	DRUMMONDII		RICHARDS. EX HOOK.	=	
DRIN 2	DRYAS	INTEGRIFOLIA		VAHL	=	
DROC	DRYAS	OCTOPETALA		L.	=MT. WASHINGTON DRYAD	
DRYOP	DRYOPTERIS			ADANS.	=WOODFERN	
DRAR	DRYOPTERIS	ARGUTA		(KAULF.) WATT	=	
DRAU 2	DRYOPTERIS	AUSTRIACA		(JACQ.) WOYNAR EX SCHINZ & THELL.	=	
DRCR 2	DRYOPTERIS	CRISTATA		(L.)	=	
DRDI	DRYOPTERIS	DILATATA		GRAY	=MOUNTAIN WOODFERN	
DRDI 2	DRYOPTERIS	DISJUNCTA		(LEDEB.) MORTON	=OAKFERN	
DRFI	DRYOPTERIS	FILIX-MAS		(L.) SCHOTT	=	
DUHO	DUGALDIA	HOOPESII		RYDB.	=	2
EATON	EATONELLA			GRAY	=EATONELLA	
EANI	EATONELLA	NIVEA		(D. C. EAT.) GRAY	=	
EBURO	EBUROPHYTON			HELLER	=PHANTOM-ORCHID; SNOW-ORCHID	
EBAU	EBUROPHYTON	AUSTINIAE		(GRAY) HELLER	=	
ECHIN2	ECHINOPS			L.	=GLOBE THISTLE	
ECSP	ECHINOPS	SPHAEROCEPHALUS		L.	=	
ECHIU	ECHIUM			L.	=ECHIUM; VIPER≠S BUGLOSS	
ECVU	ECHIUM	VULGARE		L.	=	
ELATI	ELATINE			L.	=WATERWORT; MUD-PURSLANE	
ELBR 2	ELATINE	BRACHYSPERMA		GRAY	=	
ELCA 4	ELATINE	CALIFORNICA		GRAY	=	
ELTR 2	ELATINE	TRIANDRA		SCHKUHR	=	
ELMER	ELMERA			RYDB.	=ELMERA	

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ELRA	ELMERA	RACEMOSA		(WATS.) RYDB. =	
ELODE	ELODEA			RICHARD IN MICHX. =WATERWEED; DITCHMOSS	
ELCA 3	ELODEA	CANADENSIS		RICHARD =	
ELDE	ELODEA	DENSA		(PLANCH.) CASP. =	
ELNU	ELODEA	NUTTALLII		(PLANCH.) ST. JOHN =	
ENCEL	ENCELIOPSIS			(GRAY) A. NELS. =ENCELIOPSIS	
ENNU	ENCELIOPSIS	NUDICAULIS		(GRAY) A. NELS. =	
EPILO	EPILOBIUM			L. =WILLOWWEED	
EPAD	EPILOBIUM	ADENOCAULON		HAUSSKN. =STICKY WILLOWWEED	1
EPAL	EPILOBIUM	ALPINUM		L. =ALPINE WILLOWWEED	
EPALA2	EPILOBIUM	ALPINUM	ALBIFLORUM	(SUKSD.) C. L. HITCHC. =	
EPALA	EPILOBIUM	ALPINUM	ALPINUM	L. =ALPINE WILLOWWEED	
EPALC	EPILOBIUM	ALPINUM	CLAVATUM	(TREL.) C. L. HITCHC. =	
EPALG	EPILOBIUM	ALPINUM	GRACILLIMUM	(TREL.) C. L. HITCHC. =	
EPALL	EPILOBIUM	ALPINUM	LACTIFLORUM	(HAUSSKN.) C. L. HITCHC. =	
EPAN	EPILOBIUM	ANGUSTIFOLIUM		L. =FIREWEED	
EPBR	EPILOBIUM	BREVISTYLUM		BARBEY =SIERRA WILLOWWEED	1
EPBRU	EPILOBIUM	BREVISTYLUM	URSINUM	JEPS. =	1
EPCL	EPILOBIUM	CLAVATUM		TREL. =	1
EPFA	EPILOBIUM	FASTIGIATUM		PIPER =	1
EPGL	EPILOBIUM	GLABERRIMUM		BARBEY =	
EPGL 2	EPILOBIUM	GLANDULOSUM		LEHM. =	
EPGLG	EPILOBIUM	GLANDULOSUM	GLANDULOSUM	LEHM. =	
EPGLM	EPILOBIUM	GLANDULOSUM	MACOUNII	(TREL.) C. L. HITCHC. =	
EPGLT	EPILOBIUM	GLANDULOSUM	TENUE	(TREL.) C. L. HITCHC. =	
EPHI	EPILOBIUM	HIRSUTUM		L. =	

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EPHO	EPILOBIUM	HORNEMANNII		REICHB. =HORNEMANN WILLOWWEE	1
EPJU	EPILOBIUM	JUNCUNDUM		GRAY =	1
EPLA	EPILOBIUM	LATIFOLIUM		L. =RED WILLOWWEED	
EPLU	EPILOBIUM	LUTEUM		PURSH =YELLOW WILLOWWEED	
EPMI	EPILOBIUM	MINUTUM		LINDL. EX HOOK. =	
EPOB	EPILOBIUM	OBCORDATUM		GRAY =	
EPOC	EPILOBIUM	OCCIDENTALE		RYDB. =	1
EPOR	EPILOBIUM	OREGONENSE		HAUSSKN. =	1
EPPA 2	EPILOBIUM	PALUSTRE		L. =	
EPPA	EPILOBIUM	PANICULATUM		NUTT. EX T. & G. =AUTUMN WILLOWWEED	
EPPAJ	EPILOBIUM	PANICULATUM	JUNCUNDUM	(GRAY) TREL. =	
EPSU	EPILOBIUM	SUFFRUTICOSUM		NUTT. =	
EPUR	EPILOBIUM	URSINUM		PARISH =	1
EPWA	EPILOBIUM	WATSONII		BARBEY =	
EPWAO	EPILOBIUM	WATSONII	OCCIDENTALE	(TREL.) C. L. HITCHC. =	
EPIPA	EPIPACTIS			SW. =HELLEBORINE	
EPGI	EPIPACTIS	GIGANTEA		DOUGL. EX HOOK. =	
EQUIS	EQUISETUM			L. =HORSETAIL	
EQAR	EQUISETUM	ARVENSE		L. =FIELD HORSETAIL	
EQFL	EQUISETUM	FLUVIATILE		L. =	
EQHY	EQUISETUM	HYEMALE		L. =SCOURINGRUSH	
EQLA	EQUISETUM	LAEVIGATUM		A. BR. =SMOOTH HORSETAIL	
EQPA	EQUISETUM	PALUSTRE		L. =	
EQPR	EQUISETUM	PREALTUM		RAF. =STOUT SCOURINGRUSH	1
EQSC	EQUISETUM	SCIRPOIDES		MICHX. =SEDGELIKE HORSETAIL	
EQSY	EQUISETUM	SYLVATICUM		L. =	

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EQTE	EQUISETUM	TELMATEIA		EHRH. =GIANT HORSETAIL	
EQVA	EQUISETUM	VARIEGATUM		SCHLEICH. =VARIEGATED HORSETAIL	
ERECH	ERECHTITES			RAF. =BURNWEED	
ERAR 3	ERECHTITES	ARGUTA		DC. =	
ERHI	ERECHTITES	HIERACIFOLIA		(L.) RAF. EX DC. =	
ERPR	ERECHTITES	PRENANTHOIDES		(A. RICH.) DC. =AUSTRALIAN BURNWEED	
EREMO	EREMOCARPUS			LINDL. =TURKEYMULLEIN	
ERSE	EREMOCARPUS	SETIGERUS		(HOOK.) BENTH. =TURKEYMULLEIN	
ERIAS	ERIASTRUM			WOOT. & STANDL. =ERIASTRUM	
ERSP 4	ERIASTRUM	SPARSIFLORUM		(EASTW.) MASON =	
ERSPS	ERIASTRUM	SPARSIFLORUM	SPARSIFLORUM	(EASTW.) MASON =THREADLEAVED ERIASTRUM	
ERSPW	ERIASTRUM	SPARSIFLORUM	WILCOXII	(A. NELS.) CRONQ. =	
ERIGE	ERIGERON			L. =FLEABANE; DAISY: ERIGERON	
ERAC	ERIGERON	ACRIS		L. =BITTER FLEABANE	
ERAL	ERIGERON	ALICEAE		HOWELL =ALICE FLEABANE	
ERAN	ERIGERON	ANNUUS		(L.) PERS. =ANNUAL FLEABANE	
ERAP	ERIGERON	APHANACTIS		(GRAY) GREENE =	
ERAU	ERIGERON	AUREUS		GREENE =	
ERBA 2	ERIGERON	BASALTICUS		HOOVER =	
ERBL	ERIGERON	BLOOMERI		GRAY =BLOOMER FLEABANE	
ERCA 3	ERIGERON	CAESPITOSUS		NUTT. =TUFTED FLEABANE	
ERCA 2	ERIGERON	CANADENSIS		L. =HORSEWEED FLEABANE	2
ERCH	ERIGERON	CHRYSOPSIDIS		GRAY =YELLOW FLEABANE	
ERCO	ERIGERON	COMPOSITUS		PURSH =HAIRY FLEABANE	
ERCOD	ERIGERON	COMPOSITUS	DISCOIDEUS	GRAY =	
ERCOG	ERIGERON	COMPOSITUS	GLABRATUS	MACOUN =	

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ERCOI	ERIGERON	COMPOSITUS	INCERTUS	A. NELS.	=RAYLESS FERNLEAF FLEABANE	1
ERCO 2	ERIGERON	CONCINNUS		T. & G.	=	1
ERCO 3	ERIGERON	CORYMBOSUS		NUTT.	=PURPLEDAISY FLEABANE	
ERCO 4	ERIGERON	COULTERI		PORTER	=COULTER FLEABANE	
ERDE	ERIGERON	DECUMBENS		NUTT.	=	
ERDI	ERIGERON	DIVERGENS		T. & G.	=SPREADING FLEABANE	
EREA	ERIGERON	EATONII		GRAY	=EATON FLEABANE	
EREAP	ERIGERON	EATONII	PLANTAGINEUS	(GREENE) CRONQ.	=	
EREAV	ERIGERON	EATONII	VILLOSUS	CRONQ.	=	
EREL 3	ERIGERON	ELATIOR		GREENE	=TALL FLEABANE	
EREL 5	ERIGERON	ELEGANTULUS		GREENE	=	
EREN	ERIGERON	ENGELMANNII		A. NELS.	=	
EREND	ERIGERON	ENGELMANNII	DAVISII	CRONQ.	=	
EREV	ERIGERON	EVERMANNII		RYDB.	=	
ERFI	ERIGERON	FILIFOLIUS		NUTT.	=THREADLEAF FLEABANE	
ERFL 2	ERIGERON	FLETTII		G. N. JONES	=	
ERFO	ERIGERON	FOLIOSUS		NUTT.	=	
ERFOC	ERIGERON	FOLIOSUS	CONFINIS	(HOW.) JEPS.	=LEAFY FLEABANE	
ERGL 2	ERIGERON	GLABELLUS		NUTT.	=	
ERGL	ERIGERON	GLAUCUS		KER.	=BEACH FLEABANE	
ERGR 3	ERIGERON	GRACILIS		RYDB.	=	
ERHO	ERIGERON	HOWELLII		GRAY	=	
ERIN 2	ERIGERON	INORNATUS		GRAY	=	
ERLE	ERIGERON	LEIBERGII		PIPER	=	
ERLI	ERIGERON	LINEARIS		(HOOK.) PIPER	=LINELEAF FLEABANE	
ERLO	ERIGERON	LONCHOPHYLLUS		HOOK.	=SPEARLEAF FLEABANE	

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ERMA	ERIGERON	MACRANTHUS		NUTT. =ASPEN FLEABANE	1
ERPE	ERIGERON	PEREGRINUS		(PURSH) GREENE =PEREGRINE FLEABANE	
ERPEC	ERIGERON	PEREGRINUS	CALLIANTHEMUS	(GREENE) CRONQ. =	
ERPEP	ERIGERON	PEREGRINUS	PEREGRINUS	(PURSH) GREENE =PEREGRINE FLEABANE	
ERPES	ERIGERON	PEREGRINUS	SCAPOSUS	(T. & G.) CRONQ. =	
ERPET	ERIGERON	PEREGRINUS	THOMPSONII	(BLAKE) CRONQ. =	
ERPE 2	ERIGERON	PEUCEPHYLLUS		GRAY =	1
ERPH	ERIGERON	PHILADELPHICUS		L. =PHILADELPHIA FLEABANE	
ERPI 2	ERIGERON	PIPERIANUS		CRONQ. =	
ERPO	ERIGERON	POLIOSPERMUS		GRAY =	
ERPU	ERIGERON	PUMILUS		NUTT. =LOW FLEABANE	
ERSA	ERIGERON	SALSUGINOSUS		(RICH.) GRAY =	1
ERSI	ERIGERON	SIMPLEX		GREENE =	
ERSP	ERIGERON	SPECIOSUS		(LINDL.) DC. =OREGON FLEABANE	
ERSPM	ERIGERON	SPECIOSUS	MACRANTHUS	(NUTT.) CRONQ. =	
ERSU 2	ERIGERON	SUBTRINERVIS		RYDB. =	
ERSUC	ERIGERON	SUBTRINERVIS	CONSPICUUS	(RYDB.) CRONQ. =	
ERSUS	ERIGERON	SUBTRINERVIS	SUBTRINERVIS	RYDB. =	
ERTE	ERIGERON	TENER		GRAY =	
ERTW	ERIGERON	TWEEDYI		CANBY =	
ERUR	ERIGERON	URSINUS		D. C. EAT. =BEARRIVER FLEABANE	
ERIOG	ERIOGONUM			L. =ERIOGONUM; WILD BUCKWHEAT	
ERAN 2	ERIOGONUM	ANGULOSUM		BENTH. =	1
ERBA	ERIOGONUM	BAILEYI		WATS. =	1
ERCA	ERIOGONUM	CAESPITOSUM		NUTT. =MAT ERIOGONUM	
ERCE	ERIOGONUM	CERNUUM		NUTT. =NODDING ERIOGONUM	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME ALTHORSHIP COMMON NAME	S C
ERCH 3	ERIOGONUM	CHRYSOCEPHALUM		GRAY =GOLOBALL ERIOGONUM	
ERCH 4	ERIOGONUM	CHRYSOPS		RYDB. =	
ERCO 5	ERIOGONUM	COMPOSITUM		DOUGL. EX BENTH. =NORTHERN ERIOGONUM	
ERCU	ERIOGONUM	CUSICKII		M. E. JONES =	
ERDE 2	ERIOGONUM	DEFLEXUM		TORR. =	
ERDI 2	ERIOGONUM	DICHOTOMUM		DOUGL. =	1
ERDO	ERIOGONUM	DOUGLASII		BENTH. =DOUGLAS ERIOGONUM	
EREL 2	ERIOGONUM	ELATUM		DOUGL. EX BENTH. =RUSH ERIOGONUM	
ERFL	ERIOGONUM	FLAVUM		NUTT. =	
ERHE 3	ERIOGONUM	HEERMANII		DUR. & HILG =	
ERHE	ERIOGONUM	HERACLEOIDES		NUTT. =WYETH ERIOGONUM	
ERIN	ERIOGONUM	INCANUM		T. & G. =SIERRA ERIOGONUM	
ERMA 3	ERIOGONUM	MACULATUM		HELL. =	
ERMA 2	ERIOGONUM	MARIFOLIUM		T. & G. =MOUNTAIN ERIOGONUM	
ERMI	ERIOGONUM	MICROTHECUM		NUTT. =SLENDERBUSH ERIOGONUM	
ERNI	ERIOGONUM	NIVEUM		DOUGL. EX BENTH. =SNOW ERIOGONUM	
ERNU	ERIOGONUM	NUDUM		DOUGL. EX BENTH. =BARESTEM ERIOGONUM	
EROC 2	ERIOGONUM	OCHROCEPHALUM		WATS. =	
EROCC	ERIOGONUM	OCHROCEPHALUM	CALCAREUM	(STOKES) PECK =	
EROV	ERIOGONUM	OVALIFOLIUM		NUTT. =CUSHION ERIOGONUM	
EROVM	ERIOGONUM	OVALIFOLIUM	MACROPODIUM	(GANDG.) REVEAL =	
ERPI	ERIOGONUM	PIPERI		GREENE =PIPER ERIOGONUM	1
ERPR 2	ERIOGONUM	PROLIFERUM		T. & G. =	1
ERPY	ERIOGONUM	PYROLAEFOLIUM		HOOK. EX A. MURR. =OARLEAF ERIOGONUM	
ERPYC	ERIOGONUM	PYROLAEFOLIUM	CORYPHAEUM	T. & G. =	
ERSP 2	ERIOGONUM	SPECIOSUM		DREW =	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ERSP 3	ERIOGONUM	SPHAEROCEPHALUM		DOUGL. EX BENTH. =ROCK ERIOGONUM	
ERST	ERIOGONUM	STELLATUM		BENTH. =LONGGRAY ERIOGONUM	1
ERST 2	ERIOGONUM	STRICTUM		BENTH. =	
ERSTA	ERIOGONUM	STRICTUM	ANSERINUM	STOKES =	
ERSU	ERIOGONUM	SUBALPINUM		GREENE =SUBALPINE ERIOGONUM	1
ERTE 2	ERIOGONUM	TERNATUM		HOW. =WALDO BUCKWHEAT	
ERTH	ERIOGONUM	THYMOIDES		BENTH. =THYME ERIOGONUM	
ERTO	ERIOGONUM	TOLMIEANUM		HOOK. =	1
ERUM	ERIOGONUM	UMBELLATUM		TORR. =SULFUR ERIOGONUM	
ERUMA	ERIOGONUM	UMBELLATUM	ARIDUM	(GREENE) C. L. HITCHC. =	
ERUMC	ERIOGONUM	UMBELLATUM	CHRYSANTHUM	GANDG. =	
ERUMH2	ERIOGONUM	UMBELLATUM	HAUSKNECHTII	M. E. JONES =	
ERUMH	ERIOGONUM	UMBELLATUM	HYPOLEIUM	(PIPER) C. L. HITCHC. =	
ERUMI	ERIOGONUM	UMBELLATUM	INTECTUM	A. NELS. =	
ERUMS	ERIOGONUM	UMBELLATUM	STELLATUM	M. E. JONES =	
ERUMS2	ERIOGONUM	UMBELLATUM	SUBALPINUM	(GREENE) M. E. JONES =	
ERUMT	ERIOGONUM	UMBELLATUM	TORREYANUM	(GRAY) M. E. JONES =	
ERVI	ERIOGONUM	VIMINEUM		DOUGL. =BROOM ERIOGONUM	
ERVIB	ERIOGONUM	VIMINEUM	BAILEYI	(WATS.) DAVIS =	
ERVIS	ERIOGONUM	VIMINEUM	SHOSHONENSE	(A. NELS.) STOKES =	
ERIOP2	ERIOPHYLLUM			LAG. =ERIOPHYLLUM	
ERLA	ERIOPHYLLUM	LANATUM		(PURSH) FORBES =WOOLLY ERIOPHYLLUM	
ERLAA	ERIOPHYLLUM	LANATUM	ACHILLAEOIDES	(DC.) JEPS. =	
ERLAI	ERIOPHYLLUM	LANATUM	INTEGRIFOLIUM	(HOOK.) SMILEY =SMALL WOOLLY ERIOPHYLLUM	
ERLAL	ERIOPHYLLUM	LANATUM	LANATUM	(PURSH) FORBES =	
ERLA 2	ERIOPHYLLUM	LANCEOLATUM		HOWELL =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
ERST 3	ERIOPHYLLUM	STAECHADIFOLIUM		LAG.	=LIZARDTAIL ERIOPHYLLUM	
ERWA	ERIOPHYLLUM	WATSONI		GRAY	=	1
ERITR	ERITRICHIUM			SCHRAD.	=ERITRICHIUM; FALSE FORGET-ME-NOT	
EREL	ERITRICHIUM	ELONGATUM		WIGHT	=	1
ERNA	ERITRICHIUM	NANUM		(SCHRAD.)	=	
ERNAE	ERITRICHIUM	NANUM	ELONGATUM	(RYDB.) CRONQ.	=	
ERODI	ERODIUM			L'HER.	=STORKS-BILL	
ERCI	ERODIUM	CICUTARIUM		(L.) L'HER.	=ALFILARIA; FILAREE; STORKS-BILL	
ERUCA	ERUCA			ADANS.	=ROCKET-SALAD; GARDEN-ROCKET	
ERSA 2	ERUCA	SATIVA		GARSAULT	=	
ERUCA2	ERUCASTRUM			PRESL.	=DOG MUSTARD	
ERGA	ERUCASTRUM	GALLICUM		(WILLD.) SCHULZ	=	
ERYNG	ERYNGIUM			L.	=ERYNGO	
ERAR	ERYNGIUM	ARTICULATUM		(HOOK.)	=BEETHISTLE ERYNGO	
ERPE 4	ERYNGIUM	PETIOLATUM		HOOK.	=	
ERYSI	ERYSIMUM			L.	=ERYSIMUM; WALLFLOWER	
ERAR 2	ERYSIMUM	ARENICOLA		WATS.	=	
ERAS	ERYSIMUM	ASPERUM		(NUTT.) DC.	=PLAINS ERYSIMUM	
ERCA 4	ERYSIMUM	CAPITATUM		GREENE	=COAST WALLFLOWER	1
ERCH 5	ERYSIMUM	CHEIRANTHOIDES		L.	=	
EREL 4	ERYSIMUM	ELATUM		NUTT.	=TALL ERYSIMUM	1
ERIN 3	ERYSIMUM	INCONSPICUUM		(WATS.) MACM.	=	
EROC	ERYSIMUM	OCCIDENTALE		(WATS.) ROBINS.	=	
ERRE	ERYSIMUM	REPANDUM		L.	=SPREADING ERYSIMUM	
ERTO 2	ERYSIMUM	TORULOSUM		PIPER	=NECKLACE ERYSIMUM	1
ERYTH	ERYTHRONIUM			L.	=FAWNLILY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
ERGR	ERYTHRONIUM	GRANDIFLORUM		PURSH =LAMBSTONGUE FAWNLILY	
ERGRG	ERYTHRONIUM	GRANDIFLORUM	GRANDIFLORUM	PURSH =LAMBSTONGUE FAWNLILY	
ERGRP	ERYTHRONIUM	GRANDIFLORUM	PALLIDUM	ST.JOHN =PALE LAMBSTONGUE FAWNLILY	1
ERHE 2	ERYTHRONIUM	HENDERSONII		WATS. =HENDERSON FAWNLILY	
ERMO	ERYTHRONIUM	MONTANUM		WATS. =AVALANCHE FAWNLILY	
EROR	ERYTHRONIUM	OREGONUM		APPLEG. =	
ESCHS	ESCHSCHOLZIA			CHAM. =GOLDPOPPY	
ESLE	ESCHSCHOLZIA	LEPTANDRA		GREENE =	
ESCA	ESCSCHOLZIA	CALIFORNICA		CHAM. =	
EUPAT	EUPATORIUM			L. =EUPATORIUM; BONESET	
EUOC	EUPATORIUM	OCCIDENTALE		HOOK. =WESTERN EUPATORIUM	
EUPHO	EUPHORBIA			L. =EUPHORBIA; SPURGE	
EUCR	EUPHORBIA	CRENULATA		ENGELM. =BEETLE EUPHORBIA	
EUCY	EUPHORBIA	CYPARISSIAS		L. =CYPRESS EUPHORBIA	
EUES	EUPHORBIA	ESULA		L. =	
EUGL	EUPHORBIA	GLYPTOSPERMA		ENGELM. =	
EUHE	EUPHORBIA	HELIOSCOPIA		L. =	
EULA 2	EUPHORBIA	LATHYRUS		L. =CAPER EUPHORBIA	
EUMA	EUPHORBIA	MACULATA		L. =	
EUPE	EUPHORBIA	PEPLUS		L. =	
EUSE	EUPHORBIA	SERPYLLIFOLIA		PERS. =THYMELEAF EUPHORBIA	
EUSP	EUPHORBIA	SPATHULATA		LAM. =	
EUSU	EUPHORBIA	SUPINA		RAF. =	
EUPHR	EUPHRASIA			L. =EYEBRIGHT; EUPHRASIA	
EUOF	EUPHRASIA	OFFICINALIS		L. =	
FILAG	FILAGO			L. =FILAGO; FLUFFWEED	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
FIAR	FILAGO	ARVENSIS		L. =	
FLOER	FLOERKEA			WILLD. =FALSEMERMAID	
FLPR	FLOERKEA	PROSERPINACOIDES		WILLD. =FALSEMERMAID	
FOENI	FOENICULUM			ADANS. =FENNEL	
FOVU	FOENICULUM	VULGARE		MILL. GARD. =	
FRAGA	FRAGARIA			L. =STRAWBERRY	
FRBR	FRAGARIA	BRACTEATA		HELLER =BRACTED STRAWBERRY	1
FRCA	FRAGARIA	CALIFORNICA		CHAM. & SCHLECT. =CALIFORNIA STRAWBERRY	1
FRCH	FRAGARIA	CHILOENSIS		(L.) DUCHESNE =CHILOE STRAWBERRY	
FRCU	FRAGARIA	CUNEIFOLIA		NUTT. EX T. & G. =	1
FRGL	FRAGARIA	GLAUCA		RYDB. =BLUELEAF STRAWBERRY	1
FRPL	FRAGARIA	PLATYPETALA		RYDB. =BROADPETAL STRAWBERRY	1
FRVE	FRAGARIA	VESCA		L. =	
FRVEB	FRAGARIA	VESCA	BRACTEATA	(HELLER) DAVIS =	
FRVEC	FRAGARIA	VESCA	CRINITA	(RYDB.) C. L. HITCHC. =	
FRVI	FRAGARIA	VIRGINIANA		DUCHESNE =	
FRVIG	FRAGARIA	VIRGINIANA	GLAUCA	WATS. =	
FRVIP	FRAGARIA	VIRGINIANA	PLATYPETALA	(RYDB.) HALL =	
FRANS	FRANSERIA			CAV. =BURSAGE	
FRAC	FRANSERIA	ACANTHICARPA		(HOOK.) COVILLE =	2
FRCH 2	FRANSERIA	CHAMISSONIS		LESS. =SILVER BURSAGE	2
FRASE	FRASERA			WALT. =FRASERA	
FRAL 2	FRASERA	ALBICAULIS		DOUGL. =	
FRALC2	FRASERA	ALBICAULIS	COLUMBIANA	(ST. JOHN) C. L. HITCHC. =	
FRALC	FRASERA	ALBICAULIS	CUSICKII	C. L. HITCHC. =	
FRALI	FRASERA	ALBICAULIS	IDAHOENSIS	(ST.JOHN) C. L. HITCHC. =	

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FRALN	FRASERA	ALBICAULUS	NITIDA	(BENTH.) C. L. HITCHC. =	
FRFA	FRASERA	FASTIGIATA		(PURSH) HELLER =	
FRMO	FRASERA	MONTANA		MULFORD =	
FRNI	FRASERA	NITIDA		BENTH. =SHINY FRASERA	1
FRSP	FRASERA	SPECIOSA		DOUGL. EX GRISEB. =SHOWY FRASERA	
FRITI	FRITILLARIA			L. =FRITILLARY	
FRAT	FRITILLARIA	ATROPURPUREA		NUTT. =PURPLESPOT FRITILLARY	
FRCA 2	FRITILLARIA	CAMSCHATCENSIS		(L.) KER-GAWL. =	
FRLA	FRITILLARIA	LANCEOLATA		PURSH =RICEROOT FRITILLARY	
FRPU	FRITILLARIA	PUDICA		(PURSH) SPRENG. =YELLOW FRITILLARY	
FRRE	FRITILLARIA	RECURVA		BENTH. =SCARLET FRITILLARY	
GAILL	GAILLARDIA			FOUGEROUX =GAILLARDIA	
GAAR	GAILLARDIA	ARISTATA		PURSH =COMMON PERENNIAL GAILLARDIA	
GALEO	GALEOPSIS			L. =HEMP NETTLE	
GATE	GALEOPSIS	TETRAHIT		L. =	
GALIN	GALINSOGA			CAV. =QUICKWEED; GARDEN PEST	
GACI	GALINSOGA	CILIATA		(RAF.) BLAKE =	
GALIU	GALIUM			L. =BEDSTRAW; CLEAVERS	
GAAM	GALIUM	AMBIGUM		WIGHT =OBSCURE BEDSTRAW	
GAAN	GALIUM	ANDREWSII		GRAY =NEEDLE BEDSTRAW	
GAAP	GALIUM	APARINE		L. =CATCHWEED BEDSTRAW	
GAAPA	GALIUM	APARINE	APARINE	L. =CATCHWEED BEDSTRAW	
GAAPE	GALIUM	APARINE	ECHINOSPERMUM	(WALLR.) FARW. =	
GAAS	GALIUM	ASPERRIMUM		GRAY =ROUGH BEDSTRAW	
GABI	GALIUM	BIFOLIUM		WATS. =TWINLEAF BEDSTRAW	
GABO 2	GALIUM	BOLANDERI		GRAY =BOLANDER BEDSTRAW	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
GABO	GALIUM	BOREALE		L.	=NORTHERN BEDSTRAW	
GACY	GALIUM	CYMOSUM		WIEG.	=	
GAKA	GALIUM	KAMTSCHATICUM		STELLER	=	
GAKAO	GALIUM	KAMTSCHATICUM	OREGANUM	PIPER	=	1
GAMO	GALIUM	MOLLUGO		L.	=	
GAMU	GALIUM	MULTIFLORUM		KELL.	=SHRUBBY BEDSTRAW	
GAOR	GALIUM	OREGANUM		BRITT.	=	
GAPA 2	GALIUM	PARISIENSE		L.	=	
GATR 2	GALIUM	TRICORNATUM		DANDY	=	
GATR	GALIUM	TRIFLORUM		MICHX.	=SWEETSCENTED BEDSTRAW	
GAVA	GALIUM	VAILLANTII		DC.	=	1
GAVE	GALIUM	VERUM		L.	=YELLOW BEDSTRAW	
GAURA	GAURA			L.	=GAURA	
GAPA	GAURA	PARVIFLORA		DOUGL. EX HOOK.	=	
GAYOP	GAYOPHYTUM			A. JUSS.	=GROUNDSMOKE	
GACA	GAYOPHYTUM	CAESIUM		NUTT. EX T. & G.	=	1
GADE	GAYOPHYTUM	DECIPIENS		LEWIS & SZEYK.	=	
GADI	GAYOPHYTUM	DIFFUSUM		T. & G.	=	
GAHU 2	GAYOPHYTUM	HUMILE		JUSS.	=	
GAIN	GAYOPHYTUM	INTERMEDIUM		RYDB.	=	1
GALA	GAYOPHYTUM	LASIOSPERMUM		GREENE	=	1
GANU	GAYOPHYTUM	NUTTALLII		T. & G.	=	
GANUI	GAYOPHYTUM	NUTTALLII	INTERMEDIUM	MUNZ	=	1
GANUN	GAYOPHYTUM	NUTTALLII	NUTTALLII	T. & G.	=	
GAPU	GAYOPHYTUM	PUMILUM		WATS.	=	1
GARA 2	GAYOPHYTUM	RACEMOSUM		T. & G.	=	

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GARA	GAYOPHYTUM	RAMOSISSIMUM		NUTT. EX T. & G. =HAIRSTEM GROUNDSMOKE	
GENTI	GENTIANA			L. =GENTIAN	
GEAC	GENTIANA	ACUTA		MICHX. =NORTHERN GENTIAN	1
GEAF	GENTIANA	AFFINIS		GRISEB. =ROCKYMOUNTAIN PLEATED GENTIAN	
GEAM	GENTIANA	AMARELLA		L. =	
GEAMA	GENTIANA	AMARELLA	ACUTA	(MICHX.) HERDER =	
GECA	GENTIANA	CALYCOSA		GRISEB. =RAINIER PLEATED GENTIAN	
GEDO	GENTIANA	DOUGLASIANA		BONG. =	
GENE	GENTIANA	NEWBERRYI		GRAY =	
GEOR 2	GENTIANA	OREGANA		ENGELM. EX GRAY =	1
GEPR	GENTIANA	PROSTRATA		HAENKE =	
GESA	GENTIANA	SAXICOLA		ENGLISH =	1
GESC	GENTIANA	SCEPTRUM		GRISEB. =	
GESI	GENTIANA	SIMPLEX		GRAY =	
GETE	GENTIANA	TENELLA		ROTTB. =	
GERAN	GERANIUM			L. =GERANIUM	
GEBI	GERANIUM	BICKNELLII		BRITT. =BICKNELL GERANIUM	
GECA 3	GERANIUM	CAROLINIANUM		L. =	
GECO	GERANIUM	COLUMBINUM		L. =	
GEDI	GERANIUM	DISSECTUM		L. =CUTLEAF GERANIUM	
GEIN	GERANIUM	INCISUM		NUTT. EX T. & G. =	1
GEMO	GERANIUM	MOLLE		L. =DOVEFOOT GERANIUM	
GEOR 3	GERANIUM	OREGANUM		HOWELL =OREGON GERANIUM	
GEPU	GERANIUM	PUSILLUM		BURM. =SMALL GERANIUM	
GERI	GERANIUM	RICHARDSONII		FISCH. & TRAUTV. =RICHARDSON GERANIUM	
GERO 2	GERANIUM	ROBERTIANUM		L. =	

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GEVI	GERANIUM	VISCOSISSIMUM		F. & M.	=STICKY GERANIUM	
GEVIN	GERANIUM	VISCOSISSIMUM	NERVOSUM	(RYDB.) C. L. HITCHC.	=	
GEUM	GEUM			L.	=AVENS	
GEAL	GEUM	ALEPPICUM		JACQ.	=ALEPPC AVENS	
GECA 2	GEUM	CAMPANULATUM		G. N. JONES	=REDBELL AVENS	1
GECI	GEUM	CILIATUM		PURSH	=	1
GEMA	GEUM	MACROPHYLLUM		WILLD.	=LARGELEAF AVENS	
GEMAM	GEUM	MACROPHYLLUM	MACROPHYLLUM	WILLC.	=LARGELEAF AVENS	
GEMAP	GEUM	MACROPHYLLUM	PERINCISUM	(RYDB.) RAUP	=	
GEOR	GEUM	OREGONENSE		RYDB.	=OREGON AVENS	1
GERI 2	GEUM	RIVALE		L.	=	
GERO	GEUM	ROSSII		(R. BR.) SER.	=	
GEROD	GEUM	ROSSII	DEPRESSUM	(GREENE) C. L. HITCHC.	=	
GEST	GEUM	STRICTUM		AIT.	=YELLOW AVENS	1
GETR	GEUM	TRIFLORUM		PURSH	=PRAIRIESMOKE AVENS	
GETRC	GEUM	TRIFLORUM	CAMPANULATUM	(GREENE) C. L. HITCHC.	=	
GETRC2	GEUM	TRIFLORUM	CILIATUM	(PURSH) FASSETT	=	
GETRT	GEUM	TRIFLORUM	TRIFLORUM	PURSH	=PRAIRIESMOKE AVENS	
GILIA	GILIA			RUIZ	=GILIA	
GIAG	GILIA	AGGREGATA		(PURSH) SPRENG.	=SKYROCKET GILIA	
GIBR	GILIA	BREWERI		GRAY	=	2
GICA 2	GILIA	CAPILLARIS		KELL.	=	
GICA	GILIA	CAPITATA		SIMS	=GLOBE GILIA	
GICI	GILIA	CILIATA		BENTH.	=	
GICO	GILIA	CONGESTA		HOOK.	=BALLHEAD GILIA	
GICOC	GILIA	CONGESTA	CONGESTA	HOOK.	=BALLHEAD GILIA	

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GICOV	GILIA	CONGESTA	VIRIDIS	CRONQ. =	
GIFI	GILIA	FILIFOLIA		NUTT. =WOOLYHEADED GILIA	
GIIN	GILIA	INCONSPICUA		(SM.) SWEET =SHY GILIA	1
GILE	GILIA	LEPTOMERIA		GRAY =	
GILEL	GILIA	LEPTOMERIA	LEPTOMERIA	GRAY =	
GILEM	GILIA	LEPTOMERIA	MICROMERIA	(GRAY) CRONQ. =	
GIMI	GILIA	MINUTIFLORA		BENTH. =	
GINU	GILIA	NUTTALLII		GRAY =NUTTALL GILIA	2
GIPU	GILIA	PULCHELLA		DOUGL. EX HOOK. =TINPINTE GILIA	1
GISI	GILIA	SINUATA		DOUGL. EX BENTH. =	
GISIT	GILIA	SINUATA	TWEEDYI	(RYDB.) CRONQ. =	
GISP	GILIA	SPICATA		NUTT. =	
GITE	GILIA	TENERRIMA		GRAY =	
GITHO	GITHOPSIS			NUTT. =GITHOPSIS	
GISP 2	GITHOPSIS	SPECULARIOIDES		NUTT. =	
GLAUX	GLAUX			L. =SALTWORT; SEA-MILKWORT	
GLMA	GLAUX	MARITIMA		L. =	
GLEHN	GLEHNIA			F. SCHMIDT =GLEHNIA	
GLLE 2	GLEHNIA	LEIOCARPA		MATHIAS =	
GLLI	GLEHNIA	LITTORALIS		SCHMIDT =	1
GLYCY	GLYCYRRHIZA			L. =LICORICE	
GLLE	GLYCYRRHIZA	LEPIDOTA		PURSH =AMERICAN LICORICE	
GNAPH	GNAPHALIUM			L. =CUDWEED	
GNCA	GNAPHALIUM	CALIFORNICUM		DC. =	
GNCH	GNAPHALIUM	CHILENSE		SPRENG. =	
GNMI	GNAPHALIUM	MICROCEPHALUM		NUTT. =	

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GNPA	GNAPHALIUM	PALUSTRE		NUTT. =	
GNPU	GNAPHALIUM	PURPUREUM		L. =PURPLE CUDWEED	
GNUL	GNAPHALIUM	ULIGINOSUM		L. =	
GNVI	GNAPHALIUM	VISCOSUM		H. B. K. =	
GODET	GODETIA			SPACH =GODETIA	2
GOAM	GODETIA	AMOENA		G. DON =FAREWELL-TO-SPRING GODETIA	2
GOCA	GODETIA	CAURINA		ABRAMS EX PIPER =	2
GOGR	GODETIA	GRACILIS		PIPER =	2
GOPA	GODETIA	PACIFICA		PECK =	2
GOQU	GODETIA	QUADRIVULNERA		SPACH =SMALLFLOWER GODETIA	2
GOTE	GODETIA	TENELLA		WATS. =	2
GOCO	GOMPHOCARPUS	CORDIFOLIUS		GRAY =HEARTLEAF CLUBPOD	2
GOODY	GOODYERA			R. BR. =RATTLESNAKE PLANTAIN; RATTLESNAKE ORCHID	
GODE	GOODYERA	DECIPIENS		HUBBARD =WESTERN RATTLESNAKE PLANTAIN	1
GOOB	GOODYERA	OBLONGIFOLIA		RAF. =	
GREEN	GREENEOCHARIS			GURKE & HARMS =	
GRCI	GREENEOCHARIS	CIRCUMSCISSA		RYDB. =	2
GRIND	GRINDELIA			WILLD. =GUMWEED	
GRCO	GRINDELIA	COLUMBIANA		(PIPER) RYDB. =	
GRHO	GRINDELIA	HOWELLII		STEYERM. =	
GRIN	GRINDELIA	INTEGRIFOLIA		DC. =WILLAMETTE GUMWEED	
GRINM	GRINDELIA	INTEGRIFOLIA	MACROPHYLLA	(GREENE) CRONQ. =	
GRNA	GRINDELIA	NANA		NUTT. =LOW GUMWEED	
GRSQ	GRINDELIA	SQUARROSA		(PURSH) DUNAL =CURLYCUP GUMWEED	
GRSQQ	GRINDELIA	SQUARROSA	QUASIPERENNIS	LUNELL =	
GRSQS	GRINDELIA	SQUARROSA	SERRULATA	(RYDB.) STEYERM. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
GYMNO	GYMNOCARPIUM			NEWM. =OAK-FERN	
GYDR	GYMNOCARPIUM	DRYOPTERIS		(L.) NEWM. =	
GYMNO2	GYMNOSTERIS			GREENE =GYMNOSTERIS	
GYNU	GYMNOSTERIS	NUDICAULIS		(H. & A.) GREENE =	
GYPA 2	GYMNOSTERIS	PARVULA		HELLER =	
GYPSO	GYPSOPHILA			L. =GYPSOPHILA; BABY≠S BREATH	
GYPA	GYPSOPHILA	PANICULATA		L. =	
HABEN	HABENARIA			WILLD. =HABENARIA; BOG-ORCHID	
HACH	HABENARIA	CHORISIANA		CHAM. =	
HADI 2	HABENARIA	DILATATA		(PURSH) HOOK. =WHITE BOGORCHID	
HADID	HABENARIA	DILATATA	DILATATA	(PURSH) HOOK. =WHITE BOGORCHID	
HADIL	HABENARIA	DILATATA	LEUCOSTACHYS	(LINDL.) AMES =	
HAEL	HABENARIA	ELEGANS		(LINDL.) BOLANDER =CALIFORNIA HILLSIDE HABENARIA	
HAGR 2	HABENARIA	GREENEI		JEPS. =	
HAHY	HABENARIA	HYPERBOREA		(L.) R. BR. =NORTHERN GREEN HABENARIA	
HALE	HABENARIA	LEUCOSTACHYS		WATS. =MILKWHITE HABENARIA	1
HAMA	HABENARIA	MARITIMA		GREENE =SEACLIFF HABENARIA	1
HAOB	HABENARIA	OBTUSATA		(BANKS) RICHARDS. =	
HAOR	HABENARIA	ORBICULATA		(PURSH) TORR. =	
HASA	HABENARIA	SACCATA		GREENE =	
HASP	HABENARIA	SPARSIFLORA		WATS. =CANYON HABENARIA	
HAST	HABENARIA	STRICTA		RYDB. =	1
HAUN	HABENARIA	UNALASCENSIS		(SPRENG.) WATS. =ALASKA HABENARIA	
HAVIB	HABENARIA	VIRIDIS	BRACTEATA	(MUHL) GRAY =FROG ORCHID	
HACKE	HACKELIA			OPIZ =STICKSEED; HACKELIA	
HAAR	HACKELIA	ARIDA		(PIPER) JOHNST. =	

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HACA 2	HACKELIA	CALIFORNICA		(GRAY) JOHNST. =	
HACI	HACKELIA	CILIATA		(DOUGL.) JOHNST. =	
HACI 2	HACKELIA	CINEREA		(PIPER) JOHNST. =	
HACU	HACKELIA	CUSICKII		(PIPER) BRAND =CUSICK TICKWEED	
HADA	HACKELIA	DAVISII		CRONQUIST =	
HADE	HACKELIA	DEFLEXA		(WAHLENB.) OPIZ =	
HADI	HACKELIA	DIFFUSA		(LEHM.) JOHNST. =SPREADING STICKWEED	
HAFL	HACKELIA	FLORIBUNDA		(LEHM.) JOHNST. =SHOWY STICKWEED	
HAHI 2	HACKELIA	HISPIDA		(GRAY) JOHNST. =	
HAJE	HACKELIA	JESSICAE		(MCG.) BRAND =JESSICA STICKWEED	
HAPA	HACKELIA	PATENS		(NUTT.) JOHNST. =	
HAVE	HACKELIA	VENUSTA		(PIPER) ST. JOHN =	
HALIM	HALIMOLOBOS			TAUSCH =HALIMOLOBOS	
HAPE	HALIMOLOBOS	PERPLEXA		(HENDERSON) ROLLINS =	
HAPEP	HALIMOLOBOS	PERPLEXA	PERPLEXA	(HENDERSON) ROLLINS =	
HAVI	HALIMOLOBOS	VIRGATA		(NUTT.) SCHULZ =	
HAWH	HALIMOLOBOS	WHITEDII		(PIPER) ROLLINS =	
HALOG	HALOGETON			C. A. MEY. =HALOGETON	
HAGL	HALOGETON	GLOMERATUS		C. A. MEY. =	
HAPA 2	HAMOSA	PAYSONII		RYDB. =	2
HAPLO	HAPLOPAPPUS			CASS. =GOLDENWEED; BRISTLEWEED	
HAAC	HAPLOPAPPUS	ACAULIS		(NUTT.) GRAY =STEMLESS GOLDENWEED	
HABR	HAPLOPAPPUS	BRANDEGEI		GRAY =	2
HACA	HAPLOPAPPUS	CARTHAMOIDES		(HOOK.) GRAY =	
HAHA	HAPLOPAPPUS	HALLII		GRAY =	
HAHI	HAPLOPAPPUS	HIRTUS		GRAY =	

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HAIN	HAPLOPAPPUS	INSECTICRURIS		HENDERSON	=	
HAIN 2	HAPLOPAPPUS	INTEGRIFOLIUS		GRAY	=	
HALA 2	HAPLOPAPPUS	LANCEOLATUS		(HOOK.) T. & G.	=LANCELEAF GOLDENWEED	
HALA	HAPLOPAPPUS	LANUGINOSUS		GRAY	=	
HALI	HAPLOPAPPUS	LIATRIFORMIS		(GREENE) ST.JOHN.	=	
HALY	HAPLOPAPPUS	LYALLII		GRAY	=	
HAMA 3	HAPLOPAPPUS	MACRONEMA		GRAY	=	
HANA	HAPLOPAPPUS	NANUS		(NUTT.) D. C. EAT.	=DWARF GOLDENWEED	
HARA 2	HAPLOPAPPUS	RADIATUS		(NUTT.) CRONQ.	=	
HAST 2	HAPLOPAPPUS	STENOPHYLLUS		GRAY	=	
HAUN 2	HAPLOPAPPUS	UNIFLORUS		(HOOK.) T. & G.	=	
HEDYS	HEDYSARUM			L.	=SWEETVETCH; HEDYSARUM	
HEBO	HEDYSARUM	BOREALE		NUTT.	=NORTHERN SWEETVETCH	
HEBOC	HEDYSARUM	BOREALE	CINERASCENS	(RYDB.) ROLLINS	=	
HEOC	HEDYSARUM	OCCIDENTALE		GREENE	=WESTERN SWEETVETCH	
HESU	HEDYSARUM	SULPHURESCENS		RYDB.	=	
HELEN	HELENIUM			L.	=SNEEZEWEED	
HEAU	HELENIUM	AUTUMNALE		L.	=	
HEBI	HELENIUM	BIGELOVII		GRAY	=BIGELOW SNEEZEWEED	
HEHO	HELENIUM	HOOPESII		GRAY	=ORANGE SNEEZEWEED	
HEHO 2	HELENIUM	HOOPESII		GRAY	=	
HELIA	HELIANTHELLA			T. & G.	=HELIANTHELLA; LITTLE-SUNFLOWER	
HEDO	HELIANTHELLA	DOUGLASII		T. & G.	=DOUGLAS HELIANTHELLA	1
HEQU	HELIANTHELLA	QUINQUENERVIS		(HOOK.) GRAY	=	
HEUN	HELIANTHELLA	UNIFLORA		(NUTT.) T. & G.	=ONEFLOWER HELIANTHELLA	
HEUND	HELIANTHELLA	UNIFLORA	DOUGLASII	(T. & G.) WEBER	=	

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HEUNU	HELIANTHELLA	UNIFLORA	UNIFLORA	(NUTT.) T. & G.	=ONEFLOWER HELIANTHELLA	
HELIA2	HELIANTHUS			L.	=SUNFLOWER	
HEAN	HELIANTHUS	ANNUUS		L.	=COMMON SUNFLOWER	
HECU	HELIANTHUS	CUSICKII		GRAY	=	
HEMA	HELIANTHUS	MAXIMILIANII		SCHRAD.	=	
HENU	HELIANTHUS	NUTTALLII		T. & G.	=	
HEPE	HELIANTHUS	PETIOLARIS		NUTT.	=	
HELIO	HELIOTROPIUM			L.	=HELIOTROPE	
HECU 2	HELIOTROPIUM	CURASSAVICUM		L.	=SALT HELIOTROPE	
HEMIT	HEMITOMES			GRAY	=GNOME PLANT	
HECO	HEMITOMES	CONGESTUM		GRAY	=	
HEMIZ2	HEMIZONELLA			GRAY	=(SEE MADIA)	2
HEMI 2	HEMIZONELLA	MINIMA		GRAY	=LEAST HEMIZONELLA	2
HEMIZ	HEMIZONIA			DC.	=HEMIZONIA	
HEPU 2	HEMIZONIA	PUNGENS		(H. & A.) T. & G.	=	
HERAC	HERACLEUM			L.	=COWPARSNIP	
HELA	HERACLEUM	LANATUM		MICHX.	=COMMON COWPARSNIP	
HESPE	HESPEROCHIRON			WATS.	=HESPEROCHIRON	
HECA	HESPEROCHIRON	CALIFORNICUS		(BENTH.) WATS.	=CALIFORNIA HESPEROCHIRON	
HELA 2	HESPEROCHIRON	LASIANTHUS		ST.JOHN.	=	1
HEPU	HESPEROCHIRON	PUMILUS		(GRISEB.) PORTER	=	
HETER2	HETERANTHERA			RUIZ / PAVON	=HETERANTHERA; WATER STAR-GRASS	
HEDU	HETERANTHERA	DUBIA		(JACQ.) MACMILL.	=	
HETER	HETEROCODON			NUTT.	=HETEROCODON	
HERA 2	HETEROCODON	RARIFLORUM		NUTT.	=	
HEUCH	HEUCHERA			L.	=ALUMROOT; HEUCHERA	

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HECH	HEUCHERA	CHLORANTHA		PIPER =MEADOW ALUMROOT	
HECY	HEUCHERA	CYLINDRICA		DOUGL. EX HOOK. =ROUNDLEAF ALUMROOT	
HECYA	HEUCHERA	CYLINDRICA	ALPINA	WATS. =	
HECYC	HEUCHERA	CYLINDRICA	CYLINDRICA	DOUGL. EX HOOK. =ROUNDLEAF ALUMROOT	
HECYT	HEUCHERA	CYLINDRICA	TENUIFOLIA	WHEELOCK =	1
HEGL	HEUCHERA	GLABELLA		WILLD. EX R. & S. =	1
HEGL 2	HEUCHERA	GLABRA		WILLD. EX R. & S. =	
HEGR	HEUCHERA	GROSSULARIIFOLIA		RYDB. =	
HEGRG	HEUCHERA	GROSSULARIIFOLIA	GROSSULARIIFOLIA	RYDB. =	
HEGRT	HEUCHERA	GROSSULARIIFOLIA	TENUIFOLIA	(WHEELOCK) C. L. HITCHC. =	
HEMI	HEUCHERA	MICRANTHA		DOUGL. EX LINDL. =	
HEOV	HEUCHERA	OVALIFOLIA		NUTT. =OVALLEAF ALUMROOT	1
HEPA	HEUCHERA	PARVIFOLIA		NUTT. EX T. & G. =	
HEPAD	HEUCHERA	PARVIFOLIA	DISSECTA	M. E. JONES =	
HEPAU	HEUCHERA	PARVIFOLIA	UTAHENSIS	(RYDB.) GARRETT =	
HERA	HEUCHERA	RACEMOSA		WATS. =OLYMPICS ALUMROOT	2
HERU	HEUCHERA	RUBESCENS		TORR. =RED DUMROOT	
HEUT	HEUCHERA	UTAHENSIS		RYDB. =	1
HIERA	HIERACIUM			L. =HAWKWEED	
HIAL 2	HIERACIUM	ALBERTINUM		FARR. =	
HIAL	HIERACIUM	ALBIFLORUM		HOOK. =WHITE HAWKWEED	
HICA	HIERACIUM	CANADENSE		MICHX. =CANADA HAWKWEED	
HICH	HIERACIUM	CHAPACANUM		ZAHN =	1
HICY	HIERACIUM	CYNOGLOSSOIDES		ARV. - TOUV. =HOUNDSTONGUE HAWKWEED	
HIGR	HIERACIUM	GRACILE		HOOK. =SLENDER HAWKWEED	
HIGR 2	HIERACIUM	GREENEI		GRAY =	

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HILO	HIERACIUM	LONGIBERBE		HOWELL =	
HIPI	HIERACIUM	PILOSELLA		L. =	
HIRY	HIERACIUM	RYDBERGII		ZAHN =	1
HISC	HIERACIUM	SCOULERI		HOOK. =WOOLLYWEED	
HIUM	HIERACIUM	UMBELLATUM		L. =	
HIVU 2	HIERACIUM	VULGATUM		L. =	
HIPPU	HIPPURIS			L. =MARESTAIL	
HIMO	HIPPURIS	MONTANA		LEDEB. =	
HIVU	HIPPURIS	VULGARIS		L. =MARESTAIL	
HOLOS	HOLOSTEUM			L. =JAGGED CHICKWEED	
HOUM	HOLOSTEUM	UMBELLATUM		L. =JAGGED CHICKWEED	
HORKE	HORKELIA			CHAM. & SCHLECHTD. =HORKELIA	
HOCA	HORKELIA	CAPITATA		LINDL. =	1
HOCA 2	HORKELIA	CARUIFOLIA		RYDB. =	1
HOCO	HORKELIA	CONGESTA		DOUGL. EX HOOK. =	
HODA	HORKELIA	DAUCIFOLIA		(GREENE) RYDB. =	
HOFU	HORKELIA	FUSCA		LINDL. =TAWNY HORKELIA	
HOFUC	HORKELIA	FUSCA	CAPITATA	(LINDL.) PECK =	
HOFUF	HORKELIA	FUSCA	FUSCA	LINDL. =TAWNY HORKELIA	
HOFUP	HORKELIA	FUSCA	PARVIFLORA	(NUTT.) PECK =	
HOFUT	HORKELIA	FUSCA	TENELLA	WATS. =	
HOHO	HORKELIA	HOWELLII		RYDB. =	
HOSE	HORKELIA	SERICATA		WATS. =	
HOTE	HORKELIA	TENELLA		RYDB. =	1
HOTR	HORKELIA	TRIDENTATA		TORR. =	
HODE	HOSACKIA	DENTICULATA		DREW =	2

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HOWEL	HOWELLIA			GRAY	=HOWELLIA	
HOAQ	HOWELLIA	AQUATILIS		GRAY	=	
HULSE	HULSEA			T. & G.	=HULSEA	
HUAL	HULSEA	ALGIDA		GRAY	=	
HUNA	HULSEA	NANA		GRAY	=DWARF HULSEA	
HUNAL	HULSEA	NANA	LARSENI	GRAY	=	
HUNAN	HULSEA	NANA	NANA	GRAY	=DWARF HULSEA	
HUTCH	HUTCHINSIA			R. BR.	=HUTCHINSIA	
HUPR	HUTCHINSIA	PROCUMBENS		(L.) DESV.	=	
HYDRO2	HYDROCOTYLE			L.	=MARSH-PENNYWORT	
HYRA 2	HYDROCOTYLE	RANUNCULOIDES		L.	=	
HYDRO	HYDROPHYLLUM			L.	=WATERLEAF	
HYCA	HYDROPHYLLUM	CAPITATUM		DOUGL. EX BENTH.	=BALLHEAD WATERLEAF	
HYCAA	HYDROPHYLLUM	CAPITATUM	ALPINUM	WATS.	=	
HYCAC	HYDPOPHYLLUM	CAPITATUM	CAPITATUM	DOUGL. EX BENTH.	=	
HYFE	HYDROPHYLLUM	FENDLERI		(GRAY) HELLER	=	
HYFEA	HYDROPHYLLUM	FENDLERI	ALFIFRONS	(HELLER) MACBR.	=WHITEFACE FENDLER WATERLEAF	
HYOC	HYDROPHYLLUM	OCCIDENTALE		(WATS.) GRAY	=WESTERN WATERLEAF	
HYTE	HYDROPHYLLUM	TENUIPES		HELLER	=	
HYMEN	HYMENOPAPPUS			L'HER.	=HYMENOPAPPUS	
HYFI	HYMENOPAPPUS	FILIFOLIUS		HOOK.	=	
HYMEN2	HYMENOXYS			CASS.	=HYMENOXYS	
HYGR	HYMENOXYS	GRANDIFLORA		(T. & G.) PARKER	=	
HYOSC	HYOSCYAMUS			L.	=HENBANE	
HYNI	HYOSCYAMUS	NIGER		L.	=BLACK HENBANE	
HYPER	HYPERICUM			L.	=ST. JOHNSWORT	

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HYAN	HYPERICUM	ANAGALLOIDES		C. & S. =TRAILING ST. JOHNSWORT	
HYCO	HYPERICUM	CONCINNUM		BENTH. =CALIFORNIA ST. JOHNSWORT	
HYFO	HYPERICUM	FORMOSUM		L. =	
HYFOS	HYPERICUM	FORMOSUM	SCOULERI	(HOOK.) C. L. HITCHC. =	
HYPE	HYPERICUM	PERFORATUM		L. =COMMON ST. JOHNSWORT	
HYSC	HYPERICUM	SCOULERI		HOOK. =SCOULER ST. JOHNSWORT	1
HYPOC	HYPOCHAERIS			L. =CATSEAR	
HYRA	HYPOCHAERIS	RADICATA		L. =SPOTTED CATSEAR	
HYPOP	HYPOPITYS			HILL. =PINESAP	
HYLA	HYPOPITYS	LATISQUAMA		RYDB. =	1
HYMO	HYPOPITYS	MONOTROPA		CRANTZ. =PINESAP	
HYMU	HYPOPITYS	MULTIFLORA		DC. =	1
IDAHO	IDAHOA			NELS. & MACBR. =IDAHOA; SCALEPOD	
IDSC	IDAHOA	SCAPIGERA		(HOOK.) NELS. & MACBR. =	
ILIAM	ILIAMNA			GREENE =GLOBEMALLOW	
ILLO	ILIAMNA	LONGISEPALA		(TORR.) WIGG. =	
ILRI	ILIAMNA	RIVULARIS		(DOUGL.) GREENE =	
ILRID	ILIAMNA	RIVULARIS	DIVERSA	(A. NELS.) C. L. HITCHC. =	
IMPAT	IMPATIENS			L. =BALSAM; JEWELWEED; TOUCH-ME-NOT	
IMAU	IMPATIENS	AURELLA		RYDB. =	
IMCA	IMPATIENS	CAPENSIS		MEERB. =	
IMEC	IMPATIENS	ECALCARATA		BLANK. =	
IMGL	IMPATIENS	GLANDULIFERA		ROYLE =	
IMNO	IMPATIENS	NOLI-TANGERE		L. =	
INULA	INULA			L. =INULA	
INHE	INULA	HELENIUM		L. =	

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IRIS	IRIS			L. =IRIS	
IRCH	IRIS	CHRYSOPHYLLA		HOWELL =	
IRDO	IRIS	DOUGLASIANA		HERB. =DOUGLAS IRIS	
IRHA	IRIS	HARTWEGII		BAKER =FOOTHILL IRIS	
IRMA	IRIS	MACROSIPHON		TORR. =TUBE IRIS	
IRMI	IRIS	MISSOURIENSIS		NUTT. =ROCKYMOUNTAIN IRIS	
IRPS	IRIS	PSEUDACORUS		L. =	
IRTE	IRIS	TENAX		DOUGL. EX LINDL. =OREGON IRIS	
IRTE 2	IRIS	TENUIS		WATS. =	
IRTH	IRIS	THOMPSONI		R. C. FOSTER =THOMPSON IRIS	
ISOET	ISOETES			L. =QUILLWORT	
ISBO	ISOETES	BOLANDERI		ENGELM. =	
ISHO	ISOETES	HOWELLII		ENGELM. =	
ISLA	ISOETES	LACUSTRIS		L. =	
ISNU	ISOETES	NUTALLII		A. BR. =	
ISSE	ISOETES	SETACEA		LAM. =	
ISOPY	ISOPYRUM			L. =ISOPYRUM; RUE-ANEMONE	
ISHA	ISOPYRUM	HALLII		GRAY =	
ISST	ISOPYRUM	STIPITATUM		GRAY =	
IVA	IVA			L. =SUMPWEED; POVERTY-WEED	
IVAX	IVA	AXILLARIS		PURSH =POVERTY SUMPWEED	
IVXA	IVA	XANTHIFOLIA		NUTT. =	
IVESI	IVESIA			T. & G. =IVESIA	
IVBA	IVESIA	BAILEYI		WATS. =	
IVGO	IVESIA	GORDONII		(HOOK.) T. & G. =GORDON IVESIA	
IVTW	IVESIA	TWEEDYI		RYDB. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
JAUME	JAUMEA			PERS. =JAUMEA	
JACA	JAUMEA	CARNOSA		(LESS.) GRAY =	
JUSSI	JUSSIAEA			L. =WATERPRIMROSE; WILLOW-PRIMROSE	
JUUR	JUSSIAEA	URUGUAYENSIS		CAMB. =	
KELLO	KELLOGGIA			TORR. =KELLOGGIA	
KEGA	KELLOGGIA	GALIOIDES		TORR. =	

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KICKX	KICKXIA			L. =CANCERWORT; FLUELLIN	
KIEL	KICKXIA	ELATINE		(L.) DUMCRT =	
KOBE	KOBRESIA	BELLARDII		(ALLIONI) DEGLUND. =BELLARDS KOBRESIA	
KOCHI	KOCHIA			ROTH. =KCCHIA	
KOAM	KOCHIA	AMERICANA		WATS. =RED SAGE; GREEN MCLLY	
KOSC	KOCHIA	SCOPARIA		(L.) SCHRAD. =BURNING-BUSH	
LACTU	LACTUCA			L. =LETTUCE	
LABI 2	LACTUCA	BIENNIS		(MCENCH.) FERN. =	
LALU	LACTUCA	LUDOVICIANA		(NUTT.) RIDDELL =	
LAMU	LACTUCA	MURALIS		(L.) FRESEN. =	
LAPU	LACTUCA	PULCHELLA		(PURSH) DC. =CHICORY LETTUCE	
LASE	LACTUCA	SERRIOLA		L. =PRICKLY LETTUCE	
LASEI	LACTUCA	SERRIOLA	INTEGRATA	GREN. & GODR. =	
LASES	LACTUCA	SERRIOLA	SERRIOLA	L. =PRICKLY LETTUCE	
LASP	LACTUCA	SPICATA		HITCHC. =BLUE LETTUCE	1
LAGOP	LAGOPHYLLA			NUTT. =RABBITLEAF; HARELEAF	
LARA	LAGOPHYLLA	RAMOSISSIMA		NUTT. =SLENDER RABBITLEAF	
LAMIU	LAMIUM			L. =DEADNETTLE; HENBIT	
LAAM	LAMIUM	AMPLEXICAULE		L. =HENBIT DEADNETTLE	
LAMA	LAMIUM	MACULATUM		L. =	
LAPU 2	LAMIUM	PURPJREUM		L. =	
LANGL	LANGLOISIA			GREENE =LANGLOISIA	
LASE 2	LANGLOISIA	SETOSISSIMA		(T. & G.) GREENE =	
LAPPU	LAPPULA			MOENCH =STICKSEED	
LAEC	LAPPULA	ECHINATA		GILIB. =BRISTLY STICKSEEC	
LARE	LAPPULA	REDOWSKII		(HORNEM.) GREENE =WESTERN STICKSEED	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
LAPSA	LAPSANA			L.	=LAPSANA	
LACO	LAPSANA	COMMUNIS		L.	=	
LASTH	LASTHENIA			CASS.	=LASTHENIA	
LAGL 2	LASTHENIA	GLABERRIMA		DC.	=	
LAMI	LASTHENIA	MINOR		(DC.) ORNDUFF	=	
LAMIM	LASTHENIA	MINOR	MARITIMA	(GRAY) CRONQ.	=	
LATHY	LATHYRUS			L.	=PEAVINE	
LAAP	LATHYRUS	APHACA		L.	=	
LABI	LATHYRUS	BIJUGATUS		WHITE	=	
LABIS	LATHYRUS	BIJUGATUS	SANDBERGII	WHITE	=SANDBERG PEAVINE	1
LACU	LATHYRUS	CUSICKII		WATS.	=	1
LAEU	LATHYRUS	EUCOSMUS		BUTTERS & ST.JOHN	=	
LAHI	LATHYRUS	HIRSUTUS		L.	=	
LAHO	LATHYRUS	HOLOCHLORUS		(PIPER) C. L. HITCHC.	=	
LAJA	LATHYRUS	JAPONICUS		WILLD.	=MARITIME PEAVINE	
LALA	LATHYRUS	LANCEOLATUS		HOWELL	=	1
LALA 2	LATHYRUS	LANSZWERTII		KELL.	=THICKLEAF PEAVINE	
LALAA	LATHYRUS	LANSZWERTII	ARIDUS	(PIPER) JEPS.	=	
LALAL	LATHYRUS	LANSZWERTII	LANSZWERTII	KELL.	=	
LALA 3	LATHYRUS	LATIFOLIUS		L.	=PERENNIAL PEAVINE	
LALI	LATHYRUS	LITTORALIS		(NUTT.) ENDL.	=BEACH PEAVINE	
LANE	LATHYRUS	NEVADENSIS		WATS.	=	
LANEC	LATHYRUS	NEVADENSIS	CUSICKII	(WATS.) C. L. HITCHC.	=	
LANEL	LATHYRUS	NEVADENSIS	LANCEOLATUS	(HOW.) C. L. HITCHC.	=	
LANEN	LATHYRUS	NEVADENSIS	NEVADENSIS	WATS.	=	
LANEP	LATHYRUS	NEVADENSIS	PARKERI	(ST. JOHN) C. L. HITCHC.	=	

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LANEP2	LATHYRUS	NEVADENSIS	PUNICEUS	C. L. HITCHC.	=	
LANU	LATHYRUS	NUTTALLII		WATS.	=NUTTALL PEAVINE	1
LAOB	LATHYRUS	OBOVATUS		WHITE	=	1
LAOC 2	LATHYRUS	OCHROLEUCUS		HOOK.	=CREAM PEAVINE	
LAOR	LATHYRUS	OREGONENSIS		WHITE	=	1
LAPA	LATHYRUS	PALUSTRIS		L.	=MARSH PEAVINE	
LAPA 2	LATHYRUS	PAUCIFLORUS		FERN.	=FEWFLOWERED PEAVINE	
LAPAB	LATHYRUS	PAUCIFLORUS	BROWNII	(EASTW.) PIPER	=	
LAPAT	LATHYRUS	PAUCIFLORUS	TENUIOR	PECK	=	1
LAPAU	LATHYRUS	PAUCIFLORUS	UTAHENSIS	(M. E. JONES) PECK	=	
LAPO	LATHYRUS	POLYPHYLLUS		NUTT. EX T. & G.	=PACIFIC PEAVINE	
LARI	LATHYRUS	RIGIDUS		WHITE	=	
LASC	LATHYRUS	SCHAFFNERI		RYDB.	=	
LASP 2	LATHYRUS	SPHAERICUS		RETZ.	=GRASS PEA	
LASU	LATHYRUS	SULPHUREUS		JEPS.	=SULFUR PEAVINE	
LASY	LATHYRUS	SYLVESTRIS		L.	=FLAT PEAVINE	
LATO	LATHYRUS	TORREYI		GRAY	=TORREY PEAVINE	
LAVE	LATHYRUS	VESTITUS		NUTT.	=	
LAYIA	LAYIA			H. & A.	=TIDYTIPS	
LAGL	LAYIA	GLANDULOSA		(HOOK.) H. & A.	=WHITEDAISY TIDYTIPS	
LEMNA	LEMNA			L.	=DUCKWEED	
LEMI	LEMNA	MINOR		L.	=	
LETR 2	LEMNA	TRISULCA		L.	=	
LEONT	LEONTODON			L.	=HAWKBIT	
LENU	LEONTODON	NUDICAULIS		(L.) MERAT	=	
LEPID	LEPIDIUM			L.	=PEPPERWEED	

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LECA	LEPIDIUM	CAMPESTRE		(L.) R. BR. =FIELD PEPPERWEED	
LEDE	LEPIDIUM	DENSIFLORUM		SCHRAD. =PRAIRIE PEPPERWEED	
LEDI 2	LEPIDIUM	DICTYOTUM		GRAY =	
LEDR	LEPIDIUM	DRABA		L. =HOARY PEPPERWEED	1
LELA	LEPIDIUM	LATIFOLIUM		L. =	
LEME 2	LEPIDIUM	MEDIUM		GREENE =	1
LEMO 2	LEPIDIUM	MONTANUM		NUTT. =	
LENI	LEPIDIUM	NITIDUM		NUTT. =TONGUE PEPPERWEED	
LEPE	LEPIDIUM	PERFOLIATUM		L. =CLASPING PEPPERWEED	
LERA	LEPIDIUM	RAMOSISSIMUM		A. NELS. =	
LEST	LEPIDIUM	STRICTUM		(WATS.) RATTAN =	
LEVI	LEPIDIUM	VIRGINICUM		L. =TALL PEPPERWEED	
LEPTA	LEPTARRHENA			REICHB. =FALSE SAXIFRAGE	
LEAM	LEPTARRHENA	AMPLEXIFOLIA		R. BR. EX SER. =	1
LEPY 2	LEPTARRHENA	PYROLIFOLIA		(D. DON) R. BR. =	
LEPTA2	LEPTAXIS			RAF. =	2
LEME	LEPTAXIS	MENZIESII		RAF. =	2
LEPTO2	LEPTOTAENIA			NUTT. =LEPTOTAENIA	2
LEDI	LEPTOTAENIA	DISSECTA		NUTT. =	2
LEMU	LEPTOTAENIA	MULTIFIDA		NUTT. =CARROTLEAF LEPTOTAENIA	2
LEPU	LEPTOTAENIA	PURPUREA		COULT. & ROSE =	2
LESQU	LESQUERELLA			WATS. =BLADDERPOD	
LEAL	LESQUERELLA	ALPINA		(NUTT.) WATS. =	
LEALA	LESQUERELLA	ALPINA	ALPINA	(NUTT.) WATS. =	
LEAR	LESQUERELLA	ARGENTEA		MACMILLAN =SILVER BLADDERPOD	1
LECA 2	LESQUERELLA	CARINATA		ROLLINS =	

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LEDO	LESQUERELLA	DOUGLASII		WATS. =	
LEKI	LESQUERELLA	KINGII		WATS. =	
LELU	LESQUERELLA	LUDOVICIANA		(NUTT.) WATS. =	
LEOC	LESQUERELLA	OCCIDENTALIS		WATS. =	
LEUCO	LEUCOCRINUM			NUTT. =STARLILY	
LEMO	LEUCOCRINUM	MONTANUM		NUTT. =COMMON STARLILY	
LEWIS	LEWISIA			PURSH =LEWISIA	
LECO	LEWISIA	COLUMBIANA		(HOWELL) ROBINS. =COLUMBIA LEWISIA	
LECO 2	LEWISIA	COTYLEDON		(WATS.) ROBINS. =	
LEKE	LEWISIA	KELLOGGII		BRANDG. =	
LENE	LEWISIA	NEVADENSIS		ROBINS. =NEVADA LEWISIA	1
LEPY	LEWISIA	PYGMAEA		(GRAY) ROBINS. =LEAST LEWISIA	
LERE	LEWISIA	REDIVIVA		PURSH =BITTERROOT LEWISIA	
LETR	LEWISIA	TRIPHYLLA		(WATS.) ROBINS. =THREELEAF LEWISIA	
LETW	LEWISIA	TWEEDYI		(GRAY) ROBINS. =TWEEDY LEWISIA	
LIGUS	LIGUSTICUM			L. =LIGUSTICUM; LICORICEROOT; LOVAGE	
LIAP	LIGUSTICUM	AFIIFOLIUM		(NUTT.) GRAY =	
LICA 2	LIGUSTICUM	CANBYI		COULT. & ROSE =CANBY LICORICEROOT	
LICU	LIGUSTICUM	CUSICKII		COULT. & ROSE =GRAYS LICORICEROOT	1
LIFI	LIGUSTICUM	FILICINUM		WATS. =	
LIFIT	LIGUSTICUM	FILICINUM	TENUIFOLIUM	MATH. & CONST. =FERNLEAF LIGUSTICUM	1
LIGR	LIGUSTICUM	GRAYI		COULT. & ROSE =GRAYS LICORICEROOT	
LIPU	LIGUSTICUM	PURPUREUM		COULT. & ROSE =GRAYS LICORICEROOT	1
LITE 2	LIGUSTICUM	TENUIFOLIUM		WATS. =FERNLEAF LICORICEROOT	
LIVE	LIGUSTICUM	VERTICILLATUM		(GEYER) COULT. & ROSE =	
LILAE2	LILAEOPSIS			GREENE =LILAEOPSIS	

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LIOC 2	LILAEOPSIS	OCCIDENTALIS		COULT. & ROSE	=	
LILIU	LILIUM			L.	=LILY	
LICO 4	LILIUM	COLUMBIANUM		HANSON	=COLUMBIA LILY	
LIOC	LILIUM	OCCIDENTALE		PURDY	=EUREKA LILY	
LIRU 2	LILIUM	RUBESCENS		WATS.	=CHAPARRAL LILY	
LIWA	LILIUM	WASHINGTONIANUM		KELL.	=WASHINGTON LILY	
LIMNA	LIMNANTHES			R. BR.	=MEADOWFOAM	
LIAL	LIMNANTHES	ALBA		HARTW.	=	
LIRO	LIMNANTHES	ROSEA		HARTW.	=	
LIMOS	LIMOSELLA			L.	=MUDWORT	
LIAQ	LIMOSELLA	AQUATICA		L.	=	
LINAN2	LINANTHASTRUM			EWAN	=LINANTHASTRUM	
LINU	LINANTHASTRUM	NUTTALLII		(GRAY) EWAN	=	
LINAN	LINANTHUS			BENTH.	=LINANTHUS	
LIAN	LINANTHUS	ANDROSACEUS		(BENTH.) GREENE	=	
LIBA	LINANTHUS	BAKERI		MASON	=	
LIBI	LINANTHUS	BICOLOR		(NUTT.) GREENE	=	
LIBIB	LINANTHUS	BICOLOR	BICOLOR	(NUTT.) GREENE	=	
LIGR 2	LINANTHUS	GRANDIFLORUS		(BENTH.) GREENE	=	
LIHA	LINANTHUS	HARKNESSII		(CURRAN) GREENE	=	
LIPH	LINANTHUS	PHARNACEOIDES		(BENTH.) GREENE	=	
LISE	LINANTHUS	SEPTENTRIONALIS		MASON	=NORTHERN LINANTHUS	
LINAR	LINARIA			MILL.	=TOADFLAX	
LICA 4	LINARIA	CANADENSIS		(L.) DUMONT	=	
LIDA	LINARIA	DALMATICA		(L.) MILL.	=	
LIVU 2	LINARIA	VULGARIS		HILL	=BUTTER-AND-EGGS TOADFLAX	

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LINNA	LINNAEA			L. =TWINFLOWER	
LIBO 2	LINNAEA	BOREALIS		L. =	
LIBOA	LINNAEA	BOREALIS	AMERICANA	REHD. =AMERICAN TWINFLOWER	1
LIBOL	LINNAEA	BOREALIS	LONGIFLORA	TORR. =	
LINUM	LINUM			L. =FLAX	
LIDI	LINUM	DIGYNUM		GRAY =	
LILE	LINUM	LEWISII		PURSH =LEWIS FLAX	1
LIMI	LINUM	MICRANTHUM		GRAY =	
LIPE	LINUM	PERENNE		L. =PERENNIAL FLAX	
LIPAR	LIPARIS			L. C. RICH. =LIPARIS	
LILO	LIPARIS	LOESELII		(L.) L. C. RICH. =	
LISTE	LISTERA			R. BR. =LISTERA; TWAYBLADE	
LIBO	LISTERA	BOREALIS		MORONG =	
LICA 3	LISTERA	CAURINA		PIPER =NORTHWEST LISTERA	
LICO 2	LISTERA	CONVALLARIOIDES		(SW.) NUTT. =BROADLIP LISTERA	
LICO 3	LISTERA	CORDATA		(L.) R. BR. =NORTHERN LISTERA	
LITHO	LITHOPHRAGMA			T. & G. =WOODLANDSTAR	
LIBU	LITHOPHRAGMA	BULBIFERA		RYDB. =	
LIGL	LITHOPHRAGMA	GLABRA		NUTT. =	
LIPA	LITHOPHRAGMA	PARVIFLORA		(HOOK.) NUTT. EX T. & G. =SMALLFLOWER WOODLANDSTAR	
LITE	LITHOPHRAGMA	TENELLA		NUTT. =SLENDER WOODLANDSTAR	
LITHO3	LITHOSPERMUM			L. =GROMWELL; STONESEED	
LIAR	LITHOSPERMUM	ARVENSE		L. =	
LICA	LITHOSPERMUM	CALIFORNICUM		GRAY =	
LIRU	LITHOSPERMUM	RUDERALE		DOUGL. EX LEHM. =WAYSIDE GROMWELL	
LLOYD	LLOYDIA			SALISB. =ALP LILY; LLOYDIA	

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LLSE	LLOYDIA	SEROTINA		(L.) SWEET =	
LOBEL	LOBELIA			L. =LOBELIA	
LODO 3	LOBELIA	DORTMANNA		L. =	
LOKA	LOBELIA	KALMII		L. =	
LOMAT	LOMATIUM			RAF. =BISCUITROOT; LOMATIUM; DESERT-PARSLEY	
LOAM	LOMATIUM	AMBIGUUM		(NUTT.) MATH. & CONST. =WYETH BISCUITRCCT	
LOAN	LOMATIUM	ANGUSTATUM		ST.JOHN. =	1
LOBR 2	LOMATIUM	BRADSHAWII		(ROSE) MATH. & CONST. =	
LOBR	LOMATIUM	BRANDEGEI		(COULT. & ROSE) MACBR. =	
LOCA 4	LOMATIUM	CANBYI		COULT. & ROSE =CANBY BISCUITROCT	
LOCI 2	LOMATIUM	CIRCUMDATUM		COULT. & ROSE =WALLOWA BISCUITRCOT	
LOCO 4	LOMATIUM	COLUMBIANUM		MATH. & CONST. =	
LOCO 2	LOMATIUM	COUS		(WATS.) COULT. & ROSE =COUS BISCUITROCT	
LOCU	LOMATIUM	CUSICKII		(WATS.) COULT. & ROSE =	
LOCU 2	LOMATIUM	CUSPIDATUM		MATH. & CONST. =	
LODI 2	LOMATIUM	DISSECTUM		(NUTT.) MATH & CONST. =	
LODID	LOMATIUM	DISSECTUM	DISSECTUM	(NUTT.) MATH. & CONST. =	
LODIE	LOMATIUM	DISSECTUM	EATONII	(COULT. & ROSE) CRONQ. =	
LODIM	LOMATIUM	DISSECTUM	MULTIFIDUM	(NUTT.) MATH. & CCNST. =LACE LEAVED LEPTOTAENIA	
LODO	LOMATIUM	DONNELLII		COULT. & ROSE =	
LOFA	LOMATIUM	FARINOSUM		(HOOK.) COULT. & ROSE =	
LOFO	LOMATIUM	FOENICULACEUM		(NUTT.) COULT. & ROSE =	
LOFOM	LOMATIUM	FOENICULACEUM	MACDOUGALII	(COULT. & ROSE) CRCNQ. =	
LOGE	LOMATIUM	GEYERI		(WATS.) COULT. & RCSE =GEYER BISCUITRCCT	
LOGO	LOMATIUM	GORMANII		(HOWELL) COULT. & RCSE =GCRMAN BISCUITRCOT	
LOGR	LOMATIUM	GRAYI		COULT. & ROSE =	

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LOGR 2	LOMATIUM	GREENMANII		MATHIAS =	
LOHA	LOMATIUM	HALLII		(WATS.) COULT. & ROSE =	
LOHA 2	LOMATIUM	HAMBLENIAE		MATH. & CONST. =	
LOHE	LOMATIUM	HENDERSONII		COULT. & ROSE =	
LOID	LOMATIUM	IDAHOENSE		MATH. & CONST. =	
LOLA	LOMATIUM	LAEVIGATUM		(NUTT.) COULT. & ROSE =	
LOLE	LOMATIUM	LEPTOCARPUM		(T. & G.) COULT. & ROSE =BICOLOR BISCUITROOT	
LOMA	LOMATIUM	MACROCARPUM		(NUTT.) COULT. & ROSE =BIGSEED LOMATIUM	
LOMA 2	LOMATIUM	MARTINDALEI		COULT. & ROSE =	
LOMAF	LOMATIUM	MARTINDALEI	FLAVUM	(G. N. JONES) CRONQ. =	
LOMI 2	LOMATIUM	MINUS		(ROSE) MATH. & CONST. =	
LONE	LOMATIUM	NEVADENSE		(WATS.) COULT. & ROSE =	
LONU	LOMATIUM	NUDICAULE		(PURSH) COULT. & ROSE =BARESTEM LOMATIUM	
LOOR	LOMATIUM	OREGANUM		COULT. & ROSE =	
LOOR 2	LOMATIUM	OROGENIOIDES		(COULT. & ROSE) MATHIAS =	
LOPI	LOMATIUM	PIPERI		COULT. & ROSE =	1
LORO	LOMATIUM	ROLLINSII		MATH. & CONST. =	
LOSA	LOMATIUM	SALMONIFLORUM		(COULT. & ROSE) MATH. & CONST. =	
LOSA 2	LOMATIUM	SANDBERGII		COULT. & ROSE =	
LOSE	LOMATIUM	SERPENTINUM		(M. E. JONES) MATHIAS =	
LOSI	LOMATIUM	SIMPLEX		MACBR. =NARROWLEAF LOMATIUM	1
LOSU 2	LOMATIUM	SUKSDORFII		(WATS.) COULT. & ROSE =	
LOTH	LOMATIUM	THOMPSONII		(MATHIAS) CRONQ. =	
LOTR	LOMATIUM	TRITERNATUM		(PURSH) COULT. & ROSE =NINELEAF LOMATIUM	
LOTRA	LOMATIUM	TRITERNATUM	ANOMALUM	(M. E. JONES) MATHIAS =	
LOTRM	LOMATIUM	TRITERNATUM	MACROCARPUM	(COULT. & ROSE) MATH. =	1

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LOTRP	LOMATIUM	TRITERNATUM	PLATYCARPUM	(TORR.) CRONQ. =	
LOTRT	LOMATIUM	TRITERNATUM	TRITERNATUM	(PURSH) COULT. & ROSE =NINELEAF LOMATIUM	
LOTU	LOMATIUM	TUBEROSUM		HOOVER =	
LOUT	LOMATIUM	UTRICULATUM		(NUTT.) COULT. & ROSE =POMO-CELERY LOMATIUM	
LOVA	LOMATIUM	VAGINATUM		COULT. & ROSE =	
LOWA	LOMATIUM	WATSONII		COULT. & ROSE =	
LOPHO	LOPHOTOCARPUS			DURAND =LOPHOTOCARPUS	
LOCA	LOPHOTOCARPUS	CALIFORNICUS		J. G. SM. =	2
LOTUS	LOTUS			L. =LOTUS; DEERVETCH	
LOAM 2	LOTUS	AMERICANUS		BISCH. =SPANISHCLOVER; AMERICAN LOTUS	1
LOBI	LOTUS	BICOLOR		DOUGL. EX BENTH. =	1
LOCO 3	LOTUS	CORNICULATUS		L. =BIRDSFOOT LOTUS	
LOCR	LOTUS	CRASSIFOLIUS		(BENTH.) GREENE =BIG LOTUS	
LOCRS	LOTUS	CRASSIFOLIUS	SUBGLABER	(OTTLEY) C. L. HITCHC. =	
LODE	LOTUS	DENTICULATUS		(DREW) GREENE =	
LODO 2	LOTUS	DOUGLASII		GREENE =DOUGLAS LOTUS	1
LOFO 2	LOTUS	FORMOSISSIMUS		GREENE =	
LOMI	LOTUS	MICRANTHUS		BENTH. =LITTLEFLOWER LOTUS	
LONE 2	LOTUS	NEVADENSIS		(WATS.) GREENE =NEVADA LOTUS	
LOOBT	LOTUS	OBLONGIFOLIUS	TORREYI	OTTLEY =TORREY LOTUS	
LOOB	LOTUS	OBLONGIFOLIUS		(BENTH.) GREENE =	
LOPI 2	LOTUS	PINNATUS		HOOK. =MEADOW LOTUS	
LOPU	LOTUS	PURSHIANUS		(BENTH.) C. & C. =	
LOSU	LOTUS	SUBPINNATUS		LAG. =CHILEAN LOTUS	
LOUL	LOTUS	ULIGINOSUS		SCHK. =	
LOULV	LOTUS	ULIGINOSUS	VILLOSUS	LAMOTTE =	

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LUETK	LUETKEA			BONG. =LUETKA; PARTRIDGEFOOT	
LUPE	LUETKEA	PECTINATA		(PURSH) KUNTZE =LUETKEA	
LUINA	LUINA			BENTH. =LUINA	
LUHY	LUINA	HYPOLEUCA		BENTH. =SILVERBACK LUINA	
LUNA 2	LUINA	NARDOSMIA		(GRAY) CRONQ. =	
LUNAN	LUINA	NARDOSMIA	NARDOSMIA	(GRAY) CRONQ. =	
LUSE 2	LUINA	SERPENTINA		CRONQUIST =	
LUST	LUINA	STRICTA		(GREENE) ROB. =	
LUPIN	LUPINUS			L. =LUPINE	
LUAD	LUPINUS	ADSURGENS		E. DREW =DREW LUPINE	
LUAF	LUPINUS	AFFINIS		AGARDH =	
LUAL	LUPINUS	ALBICAULIS		DOUGL. EX HOOK. =PINE LUPINE	
LUAL 2	LUPINUS	ALBIFRONS		BENTH. =	
LUALF	LUPINUS	ALBIFRONS	FLUMINEUS	C. P. SM. =	
LUAN	LUPINUS	ANDERSONI		WATS. =	1
LUAR	LUPINUS	ARBOREUS		SIMS =TREE LUPINE	
LUAR 3	LUPINUS	ARGENTEUS		PURSH =SILVERY LUPINE	
LUARA2	LUPINUS	ARGENTEUS	ARGENTEUS	PURSH =	
LUARD	LUPINUS	ARGENTEUS	DEPRESSUS	(RYDB.) C. L. HITCHC. =	
LUARP	LUPINUS	ARGENTEUS	PARVIFLORUS	(NUTT.) C. L. HITCHC. =	
LUAR 2	LUPINUS	ARIDUS		DOUGL. EX LINDL. =PRAIRIE LUPINE	1
LUARA	LUPINUS	ARIDUS	ABORTIVUS	C. P. SM. =	1
LUARC	LUPINUS	ARIDUS	CUSICKII	C. P. SM. =	1
LUART	LUPINUS	ARIDUS	TORREYI	C. P. SM. =	1
LUBI	LUPINUS	BICOLOR		LINDL. =BICOLOR LUPINE	
LUBR	LUPINUS	BREVICAULIS		WATS. =SHORTSTEM LUPINE	

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LUBR 2	LUPINUS	BREWERII		GRAY =BREWERS LUPINE	
LUBU	LUPINUS	BURKEI		WATS. =BURKE LUPINE	1
LUCA	LUPINUS	CAUDATUS		KELL. =TAILCUP LUPINE	
LUCAR	LUPINUS	CAUDATUS	RUBRICAULIS	C. P. SM. =	1
LUCO 2	LUPINUS	CORYMBOSUS		HELLER =CORYMBED LUPINE	1
LUHO	LUPINUS	HOLOSERICEUS		NUTT. =LITTLEFLOWER LUPINE	
LULA	LUPINUS	LATIFOLIUS		AGARDH. =BROADLEAF LUPINE	
LULAC	LUPINUS	LATIFOLIUS	COLUMBIANUS	(HELLER) C. P. SM. =COLUMBIA BROADLEAF	1
LULAL2	LUPINUS	LATIFOLIUS	LATIFOLIUS	AGARDH. =	
LULAL	LUPINUS	LATIFOLIUS	LONGIPES	C. P. SM. =LONGSTALK BROADLEAF LUPINE	
LULAS	LUPINUS	LATIFOLIUS	SUBALPINUS	(PIPER & ROBINS.) C. P. SM. =	
LULAT	LUPINUS	LATIFOLIUS	THOMPSONIANUS	(C. P. SM.) C. L. HITCHC. =	
LULA 2	LUPINUS	LAXIFLORUS		DOUGL. EX LINDL. =SPUR LUPINE	
LULAC2	LUPINUS	LAXIFLORUS	CALCARATUS	(KELL.) C. P. SM. =SPUR LUPINE	
LULAC3	LUPINUS	LAXIFLORUS	COGNATUS	C. P. SM. =SPUR LUPINE	1
LULAL3	LUPINUS	LAXIFLORUS	LAXIFLORUS	DOUGL. EX LINDL. =	
LULAP	LUPINUS	LAXIFLORUS	PSEUDOPARVIFLORUS	(RYDB.) SM. & ST.JOHN. =	
LULAS2	LUPINUS	LAXIFLORUS	SILVICOLA	(HELLER) C. P. SM. =SPUR LUPINE	1
LULE 2	LUPINUS	LEPIDUS		DOUGL. =	
LULEA	LUPINUS	LEPIDUS	ARIDUS	(DOUGL.) JEPS. =	
LULEC2	LUPINUS	LEPIDUS	CUSICKII	(WATS.) C. L. HITCHC. =	
LULEL3	LUPINUS	LEPIDUS	LEPIDUS	DOUGL. EX LINDL. =	
LULEL2	LUPINUS	LEPIDUS	LOBBII	(GRAY) C. L. HITCHC. =	
LULEU	LUPINUS	LEPIDUS	UTAHENSIS	(WATS.) C. L. HITCHC. =	
LULE	LUPINUS	LEUCOPHYLLUS		DOUGL. EX LINDL. =VELVET LUPINE	
LULEB	LUPINUS	LEUCOPHYLLUS	BELLIAE	C. P. SM. =	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
LULEC	LUPINUS	LEUCOPHYLLUS	CANESCENS	(HOW.) C. P. SM. =HOARY VELVET LUPINE	1
LULEL	LUPINUS	LEUCOPHYLLUS	LEUCOPHYLLUS	DOUGL. EX LINDL. =	
LULET	LUPINUS	LEUCOPHYLLUS	TENUISPICUS	(A. NELS.) C. P. SM. =	
LULI	LUPINUS	LITTORALIS		DOUGL. EX LINDL. =SHORE LUPINE	
LULY	LUPINUS	LYALLII		GRAY =LYALL LUPINE	1
LULYL	LUPINUS	LYALLII	LOBBII	C. P. SM. =LOBB LUPINE	1
LUMI	LUPINUS	MICRANTHUS		DOUGL. EX LINDL. =FIELD LUPINE	
LUMI 2	LUPINUS	MICROCARPUS		SIMS =CHICK LUPINE	
LUMIM	LUPINUS	MICROCARPUS	MICROCARPUS	SIMS =	
LUMI 3	LUPINUS	MINIMUS		DOUGL. EX HOOK. =LEAST LUPINE	1
LUNA	LUPINUS	NANUS		DOUGL. =SKY LUPINE	
LUOR	LUPINUS	ORNATUS		DOUGL. EX LINDL. =ORNATE LUPINE	1
LUPA 2	LUPINUS	PARVIFLORUS		NUTT. EX H. & A. =LODGEPOLE LUPINE	1
LUPO	LUPINUS	POLYPHYLLUS		LINDL. =WASHINGTON LUPINE	
LUPOB	LUPINUS	POLYPHYLLUS	BURKEI	(WATS.) C. L. HITCHC. =	
LUPOP	LUPINUS	POLYPHYLLUS	PALLIDIPES	(HELLER) C. P. SMITH =	
LUPOP2	LUPINUS	POLYPHYLLUS	PRUNOPHILUS	(M. E. JONES) PHILLIPS =	
LUPS	LUPINUS	PSEUDOPARVIFLORUS		RYDB. =MONTANA LUPINE	1
LUPU	LUPINUS	PUSILLUS		PURSH =RUSTY LUPINE	
LUPUI	LUPINUS	PUSILLUS	INTERMONTANUS	(HELLER) C. P. SMITH =	
LURI	LUPINUS	RIVULARIS		DOUGL. EX LINDL. =STREAM LUPINE	
LUSA 2	LUPINUS	SABINII		DOUGL. EX HOOK. =	
LUSA	LUPINUS	SAXOSUS		HOWELL =ROCK LUPINE	
LUSC	LUPINUS	SCHEJBERAE		RYDB. =	1
LUSE	LUPINUS	SERICEUS		PURSH =SILKY LUPINE	
LUSEA	LUPINUS	SERICEUS	ASOTINENSIS	(PHILLIPS) C. L. HITCHC. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
LUSEF	LUPINUS	SERICEUS	FIKERANUS	(C. P. SMITH) C. L. HITCH.	=	
LUSES	LUPINUS	SERICEUS	SERICEUS	PURSH	=WHITISH LUPINE	
LUSU 3	LUPINUS	SUBALPINUS		PIPER & ROBINS	=SUBALPINE LUPINE	1
LUSU 5	LUPINUS	SUBVEXUS		C. P. SM.	=	
LUSUT	LUPINUS	SUBVEXUS	TRANSMONTANUS	C. P. SM.	=	1
LUSU 2	LUPINUS	SUKSDORFII		ROBINS EX PIPER	=	1
LUSU	LUPINUS	SULPHUREUS		DOUGL. EX HOOK.	=SULFUR LUPINE	
LUSUK	LUPINUS	SULPHUREUS	KINCAIDII	(C. P. SMITH) C. L. HITCHC.	=	
LUSUS	LUPINUS	SULPHUREUS	SUBSACCATUS	(SUKSD.) C. L. HITCHC.	=	
LUSU 6	LUPINUS	SUPERBUS		HEL.	=	
LUSUB	LUPINUS	SUPERBUS	BERNARDINUS	ABRAMS EX C. P. SM.	=HOLLOWSTEM LUPINE	1
LUWY	LUPINUS	WYETHII		WATS.	=WYETH LUPINE	
LYCHN	LYCHNIS			L.	=CAMPION	
LYAL	LYCHNIS	ALBA		MILL.	=	
LYAP	LYCHNIS	APETALA		L.	=	
LYCO	LYCHNIS	CORONARIA		(L.) DESR.	=	
LYDI	LYCHNIS	DIOICA		L.	=	
LYDR	LYCHNIS	DRUMMONDII		(HOOK.) WATS.	=	
LYCOP	LYCOPODIUM			L.	= CLUB-MOSS	
LYAN	LYCOPODIUM	ANNOTINUM		L.	= STIFF CLUB-MOSS	
LYCL	LYCOPODIUM	CLAVATUM		L.	= RUNNINGPINE CLUB-MOSS	
LYCO 2	LYCOPODIUM	COMPLANATUM		L.	=	
LYIN	LYCOPODIUM	INUNDATUM		L.	= BOG CLUB-MOSS	
LYOB	LYCOPODIUM	OBSCURUM		L.	=	
LYSE	LYCOPODIUM	SELAGO		L.	=	
LYSI	LYCOPODIUM	SITCHENSE		RUPR. BEITR.	=	

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LYCOP2	LYCOPUS			L. =BUGLEWEED; WATER HOREHOUND	
LYAM 3	LYCOPUS	AMERICANUS		MUHL.	
LYAS	LYCOPUS	ASPER		GREENE	
LYUN	LYCOPUS	UNIFLORUS		MICHX.	
LYGOD	LYGODESMIA			D. DON =SKELETONPLANT; RUSH-PINK	
LYJU	LYGODESMIA	JUNCEA		(PURSH) C. DON	

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LYSP	LYGODESMIA	SPINOSA		NUTT.	=THORN SKELETONPLANT	
LYSIC	LYSICHITUM			SCHOTT	=YELLOWSKUNKCABBAGE	
LYAM	LYSICHITUM	AMERICANUM		HULTEN & ST.JOHN.	=AMERICAN YELLOWSKUNKCABBAGE	
LYSIM	LYSIMACHIA			L.	=LYSIMACHIA; LOOSESTRIFE	
LYNU	LYSIMACHIA	NUMMULARIA		L.	=	
LYPU	LYSIMACHIA	PUNCTATA		L.	=	
LYTE	LYSIMACHIA	TERRESTRIS		(L.) B. S. P.	=	
LYTH	LYSIMACHIA	THYRSIFLORA		L.	=	
LYTHR	LYTHRUM			L.	=LOOSESTRIFE	
LYHY	LYTHRUM	HYSSOPIFOLIA		L.	=	
LYSA	LYTHRUM	SALICARIA		L.	=	
MACHA2	MACHAERANTHERA			NEES	=TANSY ASTER	
MACA 2	MACHAERANTHERA	CANESCENS		(PURSH) GRAY.	=	
MACAT	MACHAERANTHERA	CANESCENS	TEPHRODES	(GRAY) GREENE	=	
MALA 2	MACHAERANTHERA	LAETEVIRENS		GREENE	=	
MASH	MACHAERANTHERA	SHASTENSIS		GRAY.	=	
MASHE	MACHAERANTHERA	SHASTENSIS	ERADIATA	(GRAY) CRONQ. & KECK.	=	
MASHG2	MACHAERANTHERA	SHASTENSIS	GLOSSOPHYLLUS	(PIPER) CRONQ.	=	
MASHL2	MACHAERANTHERA	SHASTENSIS	LATIFOLIA	(CRONQ.) CRONQ. & KECK	=	
MASHS2	MACHAERANTHERA	SHASTENSIS	SHASTENSIS	GRAY	=	
MATA	MACHAERANTHERA	TANACETIFOLIA		(H. B. K.) NEES.	=	
MACHA	MACHAEROCARPUS			SMALL	=FRINGED WATERPLANTAIN; MACHAEROCARPUS	
MACA	MACHAEROCARPUS	CALIFORNICUS		(TORR.) SMALL	=	
MADIA	MADIA			MOLINA	=TARWEED	
MABO	MADIA	BOLANDERI		(GRAY) GRAY	=	
MACI	MADIA	CITRIODORA		GREENE	=LEMON TARWEED	

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MADI	MADIA	DISSITIFLORA		T. & G. =COMMON TARWEED	1
MAEL	MADIA	ELEGANS		DON EX LINDL. =SHOWY TARWEED	
MAEX	MADIA	EXIGUA		(J. E. SM.) GRAY =LITTLE TARWEED	
MAGL	MADIA	GLOMERATA		HOOK. =CLUSTER TARWEED	
MAGR	MADIA	GRACILIS		(SMITH) KECK =	
MAMA	MADIA	MADIOIDES		(NUTT.) GREENE =	
MAMI	MADIA	MINIMA		(GRAY) KECK =	
MASA	MADIA	SATIVA		MOL. =	
MAIAN	MAIANTHEMUM			WEB. =BEADRUBY	
MADI 2	MAIANTHEMUM	DILATATUM		(WOOD) NELS. & MACBR. =	
MALAC	MALACOTHRIX			DC. =MALACOTHRIX	
MATO	MALACOTHRIX	TORREYI		GRAY =	
MALVA	MALVA			L. =MALLOW	
MAMO	MALVA	MOSCHATA		L. =MUSK MALLOW	
MANE 2	MALVA	NEGLECTA		WALLR. =	
MAPA	MALVA	PARVIFLORA		L. =LITTLE MALLOW	
MARO	MALVA	ROTUNDIFOLIA		L. =RUNNING MALLOW	
MASY	MALVA	SYLVESTRIS		L. =	
MARAH	MARAH			KELLOGG =BIGROOT; MANROOT	
MAOR	MARAH	OREGANUS		(T. & G.) HOWELL =OREGON BIGROOT	
MARIA	MARIANA			HILL =MARIANA	2
MALA	MARIANA	LACTEA		HILL =	2
MARRU	MARRUBIUM			BENTH. =HOARHOUND; HOREHOUND	
MAVU	MARRUBIUM	VULGARE		L. =COMMON HOARHOUND	
MARSI	MARSILEA			L. =PEPPERWORT; CLOVER-FERN	
MAVE	MARSILEA	VESTITA		HOOK. & GREV. =	

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MATRI	MATRICARIA			ADANS. =MAYWEED: MATRICARIA	
MACH	MATRICARIA	CHAMOMILLA		L. =	
MAMA 3	MATRICARIA	MARITIMA		L. =	
MAMA 2	MATRICARIA	MATRICARIOIDES		(LESS.) PORTER =PINEAPPLE-WEED	
MAZUS	MAZUS			LOUR. =MAZUS	
MAJA	MAZUS	JAPONICUS		(THUNB.) KUNTZE =	
MECON	MECONELLA			NUTT. =MECONELLA	
MEOR 2	MECONELLA	OREGANA		NUTT. =	
MEDIC	MEDICAGO			L. =MEDIC	
MEAR 2	MEDICAGO	ARABICA		(L.) HUDS. =SPOTTED MEDIC	
MEFA	MEDICAGO	FALCATA		L. =	
MELU	MEDICAGO	LUPULINA		L. =BLACK MEDIC	
MESA	MEDICAGO	SATIVA		L. =ALFALFA	
MEOR	MEGARRHIZA	OREGANA		TORR. EX WATS. =	2
MELAM	MELAMPYRUM			L. =COW-WHEAT: MELAMPYRUM	
MELI	MELAMPYRUM	LINEARE		DESR. =	
MELIL	MELILOTUS			ADANS. =SWEETCLOVER: MELILOT	
MEAL	MELILOTUS	ALBA		DESR. =WHITE SWEETCLOVER	
MEOF	MELILOTUS	OFFICINALIS		(L.) LAM. =YELLOW SWEETCLOVER	
MELIS	MELISSA			L. =BALM	
MEOF 2	MELISSA	OFFICINALIS		L. =	
MENTH	MENTHA			L. =MINT	
MEAR 3	MENTHA	ARVENSIS		L. =FIELD MINT	
MEARC	MENTHA	ARVENSIS	CANADENSIS	KUNTZE =	1
MECA	MENTHA	CANADENSIS		L. =CANADA MINT	1
MEPI	MENTHA	PIPERITA		L. =	

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MERO	MENTHA	ROTUNDIFOLIA		(L.) HUDS. =	
MESP 2	MENTHA	SPICATA		L. =	
MENTZ	MENTZELIA			L. =BLAZING-STAR; MENTZELIA	
MEAC	MENTZELIA	ACUMINATA		TIDESTROM. =	1
MEAL 2	MENTZELIA	ALBICAULIS		DOUGL. EX HOOK. =WHITESTEM MENTZELIA	
MEDE	MENTZELIA	DECAPETALA		(PURSH) URB. & GILG =	
MEDI	MENTZELIA	DISPERSA		WATS. =	
MELA 2	MENTZELIA	LAEVICAULIS		(DOUGL.) T. & G. =BLAZINGSTAR MENTZELIA	
MELAL	MENTZELIA	LAEVICAULIS	LAEVICAULIS	(DOUGL.) T. & G. =	
MELAP	MENTZELIA	LAEVICAULIS	PARVIFLORA	(DOUGL.) C. L. HITCHC. =GREAT MENTZELIA	
MENYA	MENYANTHES			L. =BOGBEAN; BUCKBEAN	
METR	MENYANTHES	TRIFOLIATA		L. =COMMON BOGBEAN	
METE	MERIMEA	TEXANA		HOOK. =	2
MERTE	MERTENSIA			ROTH. =BLUEBELLS; LUNGWORT	
MEAL 3	MERTENSIA	ALPINA		(TORR.) G. DON =	
MEBE	MERTENSIA	BELLA		PIPER =	
MEBR	MERTENSIA	BREVISTYLA		WATS. =SHORTSTYLE BLUEBELLS	
MECA 2	MERTENSIA	CAMPANULATA		A. NELS. =	
MECI	MERTENSIA	CILIATA		(TORR.) G. DON =MOUNTAIN BLUEBELLS	
MELO	MERTENSIA	LONGIFLORA		GREENE =SMALL BLUEBELLS	
MEOB	MERTENSIA	OBLIGIFOLIA		(NUTT.) G. DON =OBLONGLEAF BLUEBELLS	
MEPA	MERTENSIA	PANICULATA		(AIT.) G. DON =PANICLE BLUEBELLS	
MEPAB	MERTENSIA	PANICULATA	BOREALIS	(MACBR.) WILLIAMS =SMOOTH PANICLE BLUEBELLS	
MEPAP	MERTENSIA	PANICULATA	PANICULATA	(AIT.) G. DON =PANICLE BLUEBELLS	
MEPE	MERTENSIA	PERPLEXA		RYDB. =	
MEPL	MERTENSIA	PLATYPHYLLA		HELLER =OREGON BROADLEAF BLUEBELLS	

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MEUM	MERTENSIA	UMBRATILIS		GREENM. =	1
MEVI	MERTENSIA	VIRIDIS		A. NELS. =	
MESEM	MESEMBRYANTHEMUM			L. =MESEMBRYANTHEMUM	
MEAE	MESEMBRYANTHEMUM	AEQUILATERALE		HAW. =	
MECH	MESEMBRYANTHEMUM	CHILENSE		MOLINA =SEA FIG	
MICRO5	MICROCALA			HOFFM. & LINK. =TIMWORT	
MIQU	MICROCALA	QUADRANGULARIS		(LAM.) GRISEB. =	
MICRO	MICROMERIA			BENTH. =	2
MICH	MICROMERIA	CHAMISSONIS		GREENE =	2
MIDO	MICROMERIA	DOUGLASII		BENTH. =	2
MICRO2	MICROPUS			L. =MICROPUS	
MICA	MICROPUS	CALIFORNICUS		FISCH. & MEY. =	
MICRO3	MICROSERIS			D. DON =MICROSERIS	
MIAL 2	MICROSERIS	ALPESTRIS		(GRAY) Q. JONES =	
MIBI	MICROSERIS	BIGELOVII		(GRAY) SCHULTZ-BIP. =	
MILA	MICROSERIS	LACINIATA		(HOOK.) SCHULTZ. - BIP. =	
MILI 2	MICROSERIS	LINDLEYI		DC. =	
MILI	MICROSERIS	LINEARIFOLIA		(NUTT.) SCHULTZ - BIP. =	1
MINI	MICROSERIS	NIGRESCENS		HENDERSON =	
MINU	MICROSERIS	NUTANS		(GEYER) SCHULTZ - BIP. =NODDING MICROSERIS	
MITR	MICROSERIS	TROXIMOIDES		GRAY =	
MICRO4	MICROSTERIS			GREENE =MICROSTERIS	
MIGR	MICROSTERIS	GRACILIS		(HOOK.) GREENE =	
MIGRG	MICROSTERIS	GRACILIS	GRACILIS	(HOOK.) GREENE =	
MIGRH	MICROSTERIS	GRACILIS	HUMILIOR	(HOOK.) CRONQ. =	
MIHU	MICROSTERIS	HUMILIS		GREENE =	1

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MIMI	MICROSTERIS	MICRANTHA		GREENE =	1
MIMET	MIMETANTHE			GREENE =DOWNY MONKEY-FLOWER	
MIPI	MIMETANTHE	PILOSA		(BENTH.) GREENE =DOUGLAS MONKEYFLOWER	
MIMUL	MIMULUS			L. =MONKEYFLOWER	
MIAL	MIMULUS	ALSINOIDES		DOUGL. EX BENTH. =	
MIBR 3	MIMULUS	BREVIFLORUS		PIPER =	
MIBR 2	MIMULUS	BREWERI		(GREENE) RYDB. =BREWER MONKEYFLOWER	
MICA 2	MIMULUS	CARDINALIS		DOUGL. EX BENTH. =CRIMSON MONKEYFLOWER	
MICL	MIMULUS	CLIVICOLA		GREENM. =	
MICU	MIMULUS	CUSICKII		(GREENE) PIPER =	
MIDE	MIMULUS	DENTATUS		NUTT. EX BENTH. =	
MIFL	MIMULUS	FLORIBUNDUS		LINDL. =PURPLESTEM MONKEYFLOWER	
MIGU	MIMULUS	GUTTATUS		DC. =COMMON MONKEYFLOWER	
MIIM	MIMULUS	IMPLEXUS		GREENE =	1
MIJU	MIMULUS	JUNGERMANNIOIDES		SUKSD. =	
MILE	MIMULUS	LEWISII		PURSH =LEWIS MONKEYFLOWER	
MILUA	MIMULUS	LUTEUS	ALPINUS	GRAY =	1
MIMI 2	MIMULUS	MICROPHYLLUS		BENTH. =	1
MIMO	MIMULUS	MOSCHATUS		DOUGL. =MUSKPLANT MONKEYFLOWER	
MINA	MIMULUS	NANUS		H. & A. =DWARF MONKEYFLOWER	
MINA 2	MIMULUS	NASUTUS		GREENE =	1
MIPR	MIMULUS	PRIMULOIDES		BENTH. =PRIMROSE MONKEYFLOWER	
MIPU	MIMULUS	PULSIFERAE		GRAY =	
MISC	MIMULUS	SCOULERI		HOOK. =	1
MISU	MIMULUS	SUKSDORFII		GRAY =SUKSDORF MONKEYFLOWER	
MITI	MIMULUS	TILINGII		REGEL =	

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ITIC	MIMULUS	TILINGII	CAESPITOSUS	(GREENE) GRANT =	
MITIT	MIMULUS	TILINGII	TILINGII	REGEL =	
MITR 3	MIMULUS	TRICOLOR		HARTW. EX LINDL. =	
MIWA	MIMULUS	WASHINGTONENSIS		GAND. =	
MIRAB	MIRABILIS			L. =FOUR-CCLOCK	
MIMA	MIRABILIS	MACFARLANEI		CONST. & ROLL. =	
MINY	MIRABILIS	NYCTAGINEA		(MICHX.) MACMILLAN =	
MITEL	MITELLA			L. =MITERWORT; BISHCPS-CAP	
MIBR	MITELLA	BREWERI		GRAY =BREWER MITERWORT	
MICA 3	MITELLA	CAULESCENS		NUTT. =LEAFY MITERWORT	
MIDI	MITELLA	DIVERSIFOLIA		GREENE =	
MIOV	MITELLA	OVALIS		GREENE =	
MIPE	MITELLA	PENTANDRA		HOOK. =FIVESTAMEN MITERWORT	
MIST 2	MITELLA	STAUROPETALA		PIPER =	
MIST	MITELLA	STENOPETALA		PIPER =SMALLFLOWER MITERWCRT	1
MITR 2	MITELLA	TRIFIDA		GRAH. =	
MOEHR	MOEHRINGIA			L. =	2
MOLA	MOEHRINGIA	LATERIFLORA		FENZL. =	2
MOMA	MOEHRINGIA	MACROPHYLLA		TORR. =	2
MOLDA	MOLDAVICA			ADANS. =	2
MOPA 2	MOLDAVICA	PARVIFLORA		(NUTT.) BRITT. =	
MOLLU	MOLLUGO			L. =CARPETWEED	
MOVE	MOLLUGO	VERTICILLATA		L. =CARPETWEED	
MONAR	MONARDELLA			BENTH. =MCNARCELLA	
MODI 2	MONARDELLA	DISCOLOR		GREENE =	1
MONE	MONARDELLA	NERVOSA		GREENE =	1

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MOOD	MONARDELLA	ODORATISSIMA		BENTH. =PACIFIC MONARDELLA	
MOODD	MONARDELLA	ODORATISSIMA	DISCOLOR	(GREENE) ST.JOHN. =	
MOODO	MONARDELLA	ODORATISSIMA	ODORATISSIMA	BENTH =	
MOSH	MONARDELLA	SHELTONI		TORR. =	
MOVI	MONARDELLA	VILLOSA		BENTH. =COYOTE MINT	
MONES	MONESES			SALISB. =	2
MOUN	MONESES	UNIFLORA		GRAY =	2
MONOL	MONOLEPIS			SCHRAD. =MONOLEPIS	
MONU	MONOLEPIS	NUTTALLIANA		(SCHULTES) GREENE =NUTTALL MONOLEPIS	
MOPU	MONOLEPIS	PUSILLA		TORR. =	
MOSP 2	MONOLEPIS	SPATHULATA		GRAY =	
MONOT	MONOTROPA			L. =INDIANPIPE	
MOHY	MONOTROPA	HYPOPITYS		L. =PINESAP	
MOUN 2	MONOTROPA	UNIFLORA		L. =INDIANPIPE	
MONTI	MONTIA			L. =INDIANLETTUCE; MONTIA	
MOAR	MONTIA	ARENICOLA		(HENDERS.) HOW. =	
MOCH	MONTIA	CHAMISSOI		(LEDEB.) ROBBINS & FERN. =CHAMISSOI INDIANLETTUCE	
MOCO	MONTIA	CORDIFOLIA		(WATS.) PAX & K. HOFFM. =	
MODI	MONTIA	DICHOTOMA		(NUTT.) HOW. =DWARF MONTIA	
MODI 3	MONTIA	DIFFUSA		(NUTT.) GREENE =	
MOFO	MONTIA	FONTANA		L. =WATER INDIANLETTUCE	
MOHO	MONTIA	HOWELLII		WATS. =	
MOLI	MONTIA	LINEARIS		(DOUGL.) GREENE =LINELEAF INDIANLETTUCE	
MOPA	MONTIA	PARVIFOLIA		(MCC.) GREENE =LITTLELEAF MONTIA	
MOPE	MONTIA	PERFOLIATA		(DONN) HOW. =MINERSLETTUCE	
MOPED	MONTIA	PERFOLIATA	DEPRESSA	GRAY =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
MOSI	MONTIA	SIBIRICA		(L.) HOW.	=SIBERIAN MONTIA	
MOSP	MONTIA	SPATHULATA		(DOUGL.) HOW.	=PALE MONTIA	
MUSIN	MUSINEON			RAF.	=MUSINEON	
MUDI	MUSINEON	DIVARICATUM		(PURSH) NUTT. EX T. & G.	=	
MYOSO	MYOSOTIS			L.	=FORGETMENOT	
MYDI	MYOSOTIS	DISCOLOR		PERS.	=	
MYLA	MYOSOTIS	LAXA		LEHM.	=BAY FORGETMENOT	
MYMI	MYOSOTIS	MICRANTHA		PALL. EX LEHM.	=	
MYSC	MYOSOTIS	SCORPIOIDES		L.	=	
MYSY	MYOSOTIS	SYLVATICA		HOFFM.	=	
MYVE	MYOSOTIS	VERNA		NUTT.	=	
MYOSU	MYOSURUS			L.	=MOUSETAIL	
MYAR	MYOSURUS	ARISTATUS		BENTH. EX HOOK.	=	
MYMI 2	MYOSURUS	MINIMUS		L.	=TINY MOUSETAIL	
MYSE	MYOSURUS	SESSILIS		WATS.	=	
MYRIO	MYRIOPHYLLUM			L.	=WATER-MILFOIL	
MYBR	MYRIOPHYLLUM	BRASILIENSE		CAMB.	=	
MYEL	MYRIOPHYLLUM	PLANTINOIDES		GAUD.	=	
MYHI	MYRIOPHYLLUM	HIPPURIODES		NUTT. EX T. & G.	=	
MYSP	MYRIOPHYLLUM	SPICATUM		L.	=	
MYSPE	MYRIOPHYLLUM	SPICATUM	EXALBESCENS	(FERN.) JEPS.	=	
MYSPS	MYRIOPHYLLUM	SPICATUM	SPICATUM	L.	=	
NAMA	NAMA			L. NOM. CONSERV.	=NAMA	
NAAR	NAMA	ARETIOIDES		(H. & A.) BRAND	=	
NADE	NAMA	DENSUM		LEMMON	=	
NADED	NAMA	DENSUM	DENSUM	LEMMON	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
NADEP	NAMA	DENSUM	PARVIFLORUM	(GREENM.) C. L. HITCHC. =	
NARTH	NARTHECIUM			L. =BOGASPHODEL	
NACA	NARTHECIUM	CALIFORNICUM		BAKER =CALIFORNIA BOGASPHODEL	
NAVAR	NAVARRETIA			KTZE. =NAVARRETIA	
NABR	NAVARRETIA	BREWERI		(GRAY) GREENE =	
NADI	NAVARRETIA	DIVARICATA		(TORR.) GREENE =	
NAIN	NAVARRETIA	INTERTEXTA		(BENTH.) HOOK. =	
NAINI	NAVARRETIA	INTERTEXTA	INTERTEXTA	(BENTH.) HOOK. =	
NAINP	NAVARRETIA	INTERTEXTA	PROPINQUA	(SUKSD.) BRAND. =	
NAKL	NAVARRETIA	KLICKITATENSIS		SUKSD. =	1
NAMI	NAVARRETIA	MINIMA		NUTT. =	
NASQ	NAVARRETIA	SQUARROSA		(ESCH.) H. & A. =	
NATA	NAVARRETIA	TAGETINA		GREENE =	
NEMOP	NEMOPHILA			NUTT. =NEMOPHILA	
NEBR	NEMOPHILA	BREVIFLORA		GRAY =GREAT BASIN NEMOPHILA	
NEDE	NEMOPHILA	DENSA		HOWELL =	1
NEIN	NEMOPHILA	INCONSPICUA		HENDERS. =	1
NEKI	NEMOPHILA	KIRTLEYI		HENDERSON =	
NEME	NEMOPHILA	MENZIESII		H. & A. =	
NEPA	NEMOPHILA	PARVIFLORA		DOUGL. EX BENTH. =SMALLFLOWER NEMOPHILA	
NEPAA	NEMOPHILA	PARVIFLORA	AUSTINIAE	(EASTW.) BRAND =	
NEPE	NEMOPHILA	PEDUNCULATA		DOUGL. EX BENTH. =	
NESE	NEMOPHILA	SEPULTA		PARISH =	1
NEPET	NEPETA			L. =NEPETA	
NECA	NEPETA	CATARIA		L. =	
NEPHR	NEPHROPHYLLIDIUM			GILG. =DEER-CABBAGE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
NECR	NEPHROPHYLLIDIUM	CRISTA-GALLI		(MENZIES) GILG =	
NICOT	NICOTIANA			L. =TOBACCO	
NIAT	NICOTIANA	ATTENUATA		(GRAH.) HOOK. =COYOTE TOBACCO	
NITRO	NITROPHYLLA			WATS. =NITROPHYLLA	
NIOC	NITROPHYLLA	OCCIDENTALIS		(MOQ.) WATS. =	
NUPHA	NUPHAR			SMITH =YELLOW WATER-LILY	
NUPO	NUPHAR	POLYSEPALA		ENGELM. =	
NUVA	NUPHAR	VARIEGATUM		ENGELM. EX CLINT. =	
NYMPH	NYMPHAEA			L. =WATERLILY	
NYOD	NYMPHAEA	ODORATA		AIT. =	
NYPO	NYMPHAEA	POLYSEPALA		GREENE =	2
NYTE	NYMPHAEA	TETRAGONA		GEORGI =	
OENAN	OENANTHE			L. =WATERDROPWORT	
OECA	OENANTHE	CALIFORNICA		WATS. =	1
OESA	OENANTHE	SARMENTOSA		PRESL. EX DC. =PACIFIC WATERDROPWORT	
OEDE	OENOTHEA	DELTOIDES		TORR & FREM =	
OENOT	OENOTHERA			L. =EVENINGPRIMROSE; OENOTHERA	
OEAL	OENOTHERA	ALYSSOIDES		H. & A. =ALYSSUM EVENINGPRIMROSE	
OEAN	OENOTHERA	ANDINA		NUTT. =	
OEANH	OENOTHERA	ANDINA	HILGARDI	(GREENE) MUNZ =	
OEBI	OENOTHERA	BIENNIS		L. =COMMON EVENINGPRIMROSE	
OEBO	OENOTHERA	BOOTHII		DOUGL. EX LEHM. =	
OEBR	OENOTHERA	BREVIFLORA		T. & G. =	
OECA 2	OENOTHERA	CAESPITOSA		NUTT. =	
OECH	OENOTHERA	CHEIRANTHIFOLIA		HORNEM. EX SPRENG. =BEACH EVENINGPRIMROSE	
OECL	OENOTHERA	CLAVAEFORMIS		TORR. & FREM. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
OECO	OENOTHERA	CONTORTA		DOUGL. =	
OECOC	OENOTHERA	CONTORTA	CONTORTA	CONTORTA =	
OECOF	OENOTHERA	CONTORTA	FLEXUOSA	(A. NELS.) MUNZ =	
OEDED	OENOTHERA	DELTOIDES	DELTOIDES	TORR. & FREM. =	
OEDEP	OENOTHERA	DELTOIDES	PIPERI	MUNZ =	
OEFL	OENOTHERA	FLAVA		(A. NELS.) GARRETT =	
OEHE	OENOTHERA	HETERANTHA		NUTT. EX T. & G. =	
OEHO	OENOTHERA	HOOKERI		T. & G. =HOOKER EVENINGPRIMROSE	
OELI	OENOTHERA	LINDLEYI		DOUGL. =	2
OEMI	OENOTHERA	MINOR		(A. NELS.) MUNZ =	
OEMIC	OENOTHERA	MINOR	CUSICKII	MUNZ =	
OEMIM	OENOTHERA	MINOR	MINOR	(A. NELS.) MUNZ =	
OEPA	OENOTHERA	PALLIDA		LINDL. =PALE EVENINGPRIMROSE	
OEPA 3	OENOTHERA	PALMERI		WATS. =	
OERY	OENOTHERA	RYDBERGII		HOUSE =	1
OESC	OENOTHERA	SCAPOIDEA		NUTT. EX T. & G. =	
OETA	OENOTHERA	TANACETIFOLIA		T. / G. =TANSYLEAF EVENINGPRIMROSE	
ONVI	ONOBRYCHIS	VICIAEFOLIA		SCOP. =SAINFOIN	
ONOPO	ONOPORDUM			L. =COTTONTHISTLE; THISTLE	
ONAC	ONOPORDUM	ACANTHIUM		L. =	
OPHIO	OPHIOGLOSSUM			L. =ADDERS-TONGUE	
OPVU	OPHIOGLOSSUM	VULGATUM		L. =	
OPUNT	OPUNTIA			MILL. =PRICKLYPEAR CHOLLA	
OPER	OPUNTIA	ERINACEA		ENGELM. & BIGEL. =	
OPERX	OPUNTIA	ERINACEA	XANTHOSTEMMA	(K. SCHUM.) BENS. =	
OPFR	OPUNTIA	FRAGILIS		(NUTT.) HAW. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
OPHY	OPUNTIA	HYSTRICINA		ENGELM. & BIGEL. =	
OPPO	OPUNTIA	POLYCANTHA		HAW. =PLAINS PRICKLYPEAR	
OPRH	OPUNTIA	RHODANTHA		K. SCHUM. =	1
ORIGA	ORIGANUM			L. =WILD MARJORAM	
ORVU	ORIGANUM	VULGARE		L. =	
OROBA	OROBANCHE			L. =BROOMRAPE	
ORCA	OROBANCHE	CALIFORNICA		CHAM. & SCHLECHT. =	
ORFA 2	OROBANCHE	FASCICULATA		NUTT. =	
ORGR	OROBANCHE	GRAYANA		BECK =	
ORLU 2	OROBANCHE	LUDOVICIANA		NUTT. =	
ORMI	OROBANCHE	MINOR		J. E. SMITH =	
ORPI	OROBANCHE	PINORUM		GEYER =	
ORUN	OROBANCHE	UNIFLORA		L. =	
ORUNM	OROBANCHE	UNIFLORA	MINUTA	(SUKSD.) BECK =	
ORUNP	OROBANCHE	UNIFLORA	PURPUREA	(HELLER) ACHEY =	
OROGE	OROGENIA			WATS. =OROGENIA; TURKEY-PEAS	
ORFU	OROGENIA	FUSIFORMIS		WATS. =	
ORLI	OROGENIA	LINEARIFOLIA		WATS. =	
ORTHO	ORTHOCARPUS			NUTT. =OWLCLOVER; OWLWEED	
ORAT	ORTHOCARPUS	ATTENUATUS		GRAY =VALLEYTASSELS OWLCLOVER	
ORBA 2	ORTHOCARPUS	BARBATUS		COTTON =	
ORBR	ORTHOCARPUS	BRACTEOSUS		BENTH. =	
ORCA 2	ORTHOCARPUS	CASTILLEJOIDES		BENTH. =	
ORCOC	ORTHOCARPUS	COPELANDII	CRYPTANTHUS	(PIPER) KECK =	
ORCR	ORTHOCARPUS	CRYPTANTHUS		PIPER =	1
ORCU	ORTHOCARPUS	CUSPIDATUS		GREENE =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
ORER	ORTHOCARPUS	ERIANTHUS		BENTH. =JOHNNYTUCK OWLCLOVER	
ORFA	ORTHOCARPUS	FAUCIBARBATUS		GRAY =	
ORHI	ORTHOCARPUS	HISPIDUS		BENTH. =	
ORIM	ORTHOCARPUS	IMBRICATUS		TORR. EX WATS. =	
ORLA	ORTHOCARPUS	LACERUS		BENTH. =	
ORLU	ORTHOCARPUS	LUTEUS		NUTT. =YELLOW OWLCLOVER	
ORPU	ORTHOCARPUS	PUSILLUS		BENTH. =	
ORTE	ORTHOCARPUS	TENUIFOLIUS		(PURSH) BENTH. =	
OSMOR	OSMORHIZA			RAF. =SWEETROOT	
OSBR	OSMORHIZA	BREVIPES		SUKSD. =	1
OSCH	OSMORHIZA	CHILENSIS		H. & A. =	
OSDE	OSMORHIZA	DEPAUPERATA		PHIL. =	
OSDI	OSMORHIZA	DIVARICATA		NUTT. EX T. & G. =SPREADING SWEETROOT	1
OSNU	OSMORHIZA	NUDA		TORR. =	1
OSOC	OSMORHIZA	OCCIDENTALIS		(NUTT.) TORR. =SWEETANISE	
OSPU	OSMORHIZA	PURPUREA		(COULT. & ROSE) SUKSD. =	
OXALI	OXALIS			L. =OXALIS	
OXCO	OXALIS	CORNICULATA		L. =	
OXOR	OXALIS	OREGANA		NUTT. EX T. & G. =OREGON OXALIS	
OXST	OXALIS	STRICTA		L. =	
OXSU	OXALIS	SUKSDORFII		TREL. =	
OXTR	OXALIS	TRILLIIFOLIA		HOOK. =	
OXYRI	OXYRIA			HILL =MOUNTAINSORREL	
OXDI	OXYRIA	DIGYNA		(L.) HILL =ALPINE MOUNTAINSORREL	
OXYTH	OXYTHECA			NUTT. =OXYTHECA	
OXDE	OXYTHECA	DENDROIDEA		NUTT. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME ALTHORSHIP COMMON NAME	SC
OXYTR	OXYTROPIS			DC. =CRAZYWEED: OXYTROPE	
OXBE	OXYTROPIS	BESSEYI		(RYDB.) ELANK. =	
OXBEA	OXYTROPIS	BESSEYI	ARGOPHYLLA	(RYDB.) BARNEBY =	
OXBEB	OXYTROPIS	BESSEYI	BFSSEYI	(RYDB.) ELANK. =	
OXBES	OXYTROPIS	BESSEYI	SALMONENSIS	BARNEBY =	
OXCAC	OXYTROPIS	CAMPESTRIS	COLUMBIANA	(ST. JOHN) BARNEBY =	
OXCAC2	OXYTROPIS	CAMPESTRIS	CUSICKII	(GREENM.) BARNEBY =	
OXCAG	OXYTROPIS	CAMPESTRIS	GRACILIS	(A. NELS.) BARNEBY =	
OXCO 2	OXYTROPIS	COMPESTRIS		(L.) DC =	
OXDE 2	OXYTROPIS	DEFLEXA		(PALL.) CC. =	
OXDED	OXYTROPIS	DEFLEXA	DEFLEXA	(PALL.) CC. =	
OXDES	OXYTROPIS	DEFLEXA	SERICEA	T. & G. =	
OXLA	OXYTROPIS	LAGOPUS		NUTT. =	
OXLAL	OXYTROPIS	LAGOPUS	LAGOPUS	NUTT. =	
OXLU	OXYTROPIS	LLTEOLA		PIPER & EEATTIE =	1
OXPA	OXYTROPIS	PARRYI		GRAY =	
OXSE	OXYTROPIS	SERICEA		NUTT. =	
OXSES	OXYTROPIS	SERICEA	SERICEA	NUTT. =	
OXSES2	OXYTROPIS	SERICEA	SPICATA	(HOOK.) BARNEBY =	
OXVI	OXYTROPIS	VISCIDA		NUTT. =	
PAEON	PAEONIA			L. =PEONY	
PABR	PAEONIA	BROWNII		DOUGL. EX HOOK. =BROWNS PEONY	
PAPAV	PAPAVER			L. =POPPY	
PAAR	PAPAVER	ARGEMONE		L. =	
PASO	PAPAVER	SOMNIFERUM		L. =	
PAREN	PARENTUCELLIA			VIVIANI =PARENTUCELLIA	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
PAVI	PARENTUCELLIA	VISCOSA		(L.) CAR.	=	
PARIE	PARIETARIA			L.	=PELLITORY	
PAPE	PARIETARIA	PENNSYLVANICA		MUHL. EX WILLD.	=	
PARNA	PARNASSIA			L.	=PARNASSIA; GRASS-OF-PARNASSUS	
PACA 2	PARNASSIA	CALIFORNICA		GREENE	=CALIFORNIA PARNASSIA	1
PAFI	PARNASSIA	FIMBRIATA		KONIG.	=ROCKYMOUNTAIN PARNASSIA	
PAKO	PARNASSIA	KOTZEBUEI		CHAM.	=	
PAKOK	PARNASSIA	KOTZEBUEI	KOTZEBUEI	CHAM.	=	
PAKOP	PARNASSIA	KOTZEBUEI	PUMILA	HITCHC. & OWNBEY	=	
PAPA	PARNASSIA	PALUSTRIS		L.	=WIDEWORLD PARNASSIA	
PAPAC	PARNASSIA	PALUSTRIS	CALIFORNICA	GRAY	=	
PAPA 3	PARNASSIA	PARVIFLORA		DC.	=	
PECTO	PECTOCARYA			DC.	=COMBSEED	
PELI 2	PECTOCARYA	LINEARIS		(R. & P.) DC.	=	
PELIL	PECTOCARYA	LINEARIS	LINEARIS	(R. & P.) DC.	=	
PEPU	PECTOCARYA	PUSILLA		(A. DC.) GRAY	=LITTLE PECTOCARYA	
PESE 2	PECTOCARYA	SETOSA		GRAY	=	
PEDIC	PEDICULARIS			L.	=PEDICULARIS	
PEAT 2	PEDICULARIS	ATROSANGUINEA		PENNELL & THOMPS.	=	1
PEAT 3	PEDICULARIS	ATTOLLENS		GRAY	=	
PEBR	PEDICULARIS	BRACTEOSA		BENTH.	=BRACTED PEDICULARIS	
PEBRA	PEDICULARIS	BRACTEOSA	ATROSANGUINEA	(PENNELL & THOMPSON) CRONQ.	=	
PEBRF	PEDICULARIS	BRACTEOSA	FLAVIDA	(PENNELL) CRONQ.	=	
PEBRP	PEDICULARIS	BRACTEOSA	PACHYRHIZA	(PENNELL) CRONQ.	=	
PECE	PEDICULARIS	CENTRANTHERA		GRAY	=DWARF PEDICULARIS	
PECO 2	PEDICULARIS	CONTORTA		BENTH.	=COILED PEDICULARIS	

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PEDE 2	PEDICULARIS	DENSIFLORA		BENTH. EX HOOK. =INDIANWARRIOR PEDICULARIS
PEGR	PEDICULARIS	GROENLANDICA		RETZ. =ELEPHANTHEAD PEDICULARIS
PEOR 5	PEDICULARIS	ORNITHORHYNCHA		BENTH. =
PERA	PEDICULARIS	RACEMOSA		DOUGL. EX HOOK. =SICKLETOP PEDICULARIS
PERAA	PEDICULARIS	RACEMOSA	ALBA	(PENNELL) CRONQ. =
PERA 5	PEDICULARIS	RAINIERENSIS		PENNELL & WARREN =
PEDIO	PEDIOCACTUS			BRITT. & ROSE =HEDGEHOG-CACTUS
PESI	PEDIOCACTUS	SIMPSONII		(ENGELM.) BRITT. & ROSE =
PELLA	PELLAEA			LINK =CLIFFBRAKE
PEBR 2	PELLAEA	BRACHYPTERA		(T. MOORE) BAKER =SIERRA CLIFFBRAKE
PEBR 3	PELLAEA	BREWERI		D. C. EAT. =BREWERS CLIFFBRAKE
PEBR 4	PELLAEA	BRIDGESII		HOOK. =
PEGL 5	PELLAEA	GLABELLA		METT. EX JAHN =
PEGLO	PELLAEA	GLABELLA	OCCIDENTALIS	(E. NELS.) BUTTERS =
PEGLS	PELLAEA	GLABELLA	SIMPLEX	BUTTERS =
PEOC	PELLAEA	OCCIDENTALIS		(E. NELS.) BUTTERS =
PELTI	PELTIPHYLLUM			ENGL. =SHIELDLEAF; UMBRELLA-PLANT; INDIAN RHUBARB
PEPE	PELTIPHYLLUM	PELTATUM		(TORR.) ENGL. =UMBRELLA SAXIFRAGE
PENST	PENSTEMON			MITCH. =PENSTEMON
PEAC	PENSTEMON	ACUMINATUS		DOUGL. EX LINDL. =SHARP-LEAVED PENSTEMON
PEAL	PENSTEMON	ALBERTINUS		GREENE =
PEAL 2	PENSTEMON	ALBIDUS		NUTT. =
PEAR	PENSTEMON	ARIDUS		RYDB. =STIFFLEAF PENSTEMON
PEAT	PENSTEMON	ATTENUATUS		DOUGL. EX LINDL. =SULFUR PENSTEMON
PEATM	PENSTEMON	ATTENUATUS	MILITARIS	(GREENE) CRONQ. =
PEATP2	PENSTEMON	ATTENUATUS	PALUSTRIS	(PENNELL) CRONQ. =

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
PEATP	PENSTEMON	ATTENUATUS	PSEUDOPROCERUS	(RYDB.) CRONG. =	
PEBA	PENSTEMON	BARRETTIAE		GRAY =	
PECA	PENSTEMON	CACUMINIS		PENNELL =	1
PECA 3	PENSTEMON	CARDWELLII		HOWELL =	
PECH	PENSTEMON	CHIONOPHILUS		GREENE =SNOWLAND PENSTEMON	1
PECI	PENSTEMON	CINICOLA		KECK =	
PECO	PENSTEMON	CONFERTUS		DOUGL. =YELLOW PENSTEMON	
PECU	PENSTEMON	CUSICKII		GRAY =CUSICK PENSTEMON	
PECY	PENSTEMON	CYANEUS		PENNELL =	
PEDA	PENSTEMON	DAVIDSONII		GREENE =DAVIDSON PENSTEMON	
PEDAM	PENSTEMON	DAVIDSONII	MENZIESII	(KECK) CRONG. =	
PEDE	PENSTEMON	DEUSTUS		DOUGL. EX LINDL. =SCABLAND PENSTEMON	
PEDED	PENSTEMON	DEUSTUS	DEUSTUS	DOUGL. EX LINDL. =	
PEDEH	PENSTEMON	DEUSTUS	HETERANDER	(T. & G.) CRONQ. =	
PEDEV	PENSTEMON	DEUSTUS	VARIABILIS	(SUKSD.) CRONQ. =	
PEDI	PENSTEMON	DIPHYLLUS		RYDB. =	
PEEL	PENSTEMON	ELEGANTULUS		PENNELL =	
PEEL 2	PENSTEMON	ELLIPTICUS		COULT. & FISH. =	
PEER	PENSTEMON	ERIANTHERUS		PURSH =FUZZYTONGUE PENSTEMON	
PEERA	PENSTEMON	ERIANTHERUS	ARGILLOSUS	M. E. JONES =	
PEERE	PENSTEMON	ERIANTHERUS	ERIANTHERUS	PURSH =	
PEERR	PENSTEMON	ERIANTHERUS	REDACTUS	PENNELL & KECK =	
PEERW	PENSTEMON	ERIANTHERUS	WHITEDII	(PIPER) A. NELS. =	
PEEU	PENSTEMON	EUGLAUCUS		ENGLISH =	
PEFL	PENSTEMON	FLAVESCENS		PENNELL =	
PEFR 3	PENSTEMON	FRUITICOSUS		(PURSH) GREENE =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
PEFRS2	PENSTEMON	FRUITICOSUS	SERRATUS	(KECK) CRONQ. =	
PEFRF	PENSTEMON	FRUTICOSUS	FRUTICOSUS	(PURSH) GREENE =BUSH PENSTEMON	
PEFRS	PENSTEMON	FRUTICOSUS	SCOULERI	(LINDL.) CRONQ. =	
PEGA	PENSTEMON	GAIRDNERI		HOOK. =GAIRDNER PENSTEMON	
PEGAO	PENSTEMON	GAIRDNERI	OREGANUS	GRAY =	
PEGL 2	PENSTEMON	GLABER		JEPS. =SAWSEPAL PENSTEMON	1
PEGL	PENSTEMON	GLANDULOSUS		DOUGL. =STICKYSTEM PENSTEMON	
PEGLC	PENSTEMON	GLANDULOSUS	CHELANENSIS	(KECK) CRONQ. =	
PEGL 4	PENSTEMON	GLOBOSUS		(PIPER) PENNELL & KECK =	
PEGR 2	PENSTEMON	GRACILENTUS		GRAY =SLIMSTEM PENSTEMON	
PEGR 3	PENSTEMON	GRACILIS		NUTT. =	
PEHU	PENSTEMON	HUMILIS		NUTT. EX GRAY =LOW PENSTEMON	
PEKI	PENSTEMON	KINGII		KELLOGG =KINGS PENSTEMON	
PELA	PENSTEMON	LAETUS		GRAY =GAY PENSTEMON	
PELAL	PENSTEMON	LAETUS	LAETUS	GRAY =GAY PENSTEMON	
PELAR	PENSTEMON	LAETUS	ROEZLII	(REGEL) JEPS. =	
PELA 2	PENSTEMON	LAXUS		A. NELS. =	
PELE	PENSTEMON	LEMHIENSIS		(KECK) KECK & CRONQ. =	
PELI	PENSTEMON	LINEOLATUS		GREENE =HUMBOLDT PENSTEMON	
PELY	PENSTEMON	LYALLII		GRAY =	
PEME	PENSTEMON	MENZIESII		HOOK. =MENZIES PENSTEMON	1
PEMI	PENSTEMON	MICRANTHUS		NUTT. =TINYBLOOM PENSTEMON	1
PEMO	PENSTEMON	MONTANUS		GREENE =	
PEMOM	PENSTEMON	MONTANUS	MONTANUS	GREENE =	
PENE 2	PENSTEMON	NEMOROSUS		(DOUGL.) TRAUTV. =GROVE PENSTEMON	2
PENE	PENSTEMON	NEWBERRYI		GRAY =NEWBERRY PENSTEMON	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
PENI 2	PENSTEMON	NITIDUS		DOUGL. EX BENTH. =	
PENIN	PENSTEMON	NITIDUS	NITIDUS	DOUGL. EX BENTH. =	
PENIP	PENSTEMON	NITIDUS	POLYPHYLLUS	(PENNELL) CRONQ. =	
PEOR	PENSTEMON	OREGANUS		HOWELL =OREGON PENSTEMON	1
PEOR 3	PENSTEMON	OREOCHARIS		GREENE =	1
PEOV	PENSTEMON	OVATUS		DOUGL. =EGGLEAF PENSTEMON	
PEPA 2	PENSTEMON	PAYETTENSIS		NELS. & MACBR. =	
PEPE 2	PENSTEMON	PECKII		PENNELL =	
PEPE 3	PENSTEMON	PENNELLIANUS		KECK =	
PEPR	PENSTEMON	PROCERUS		DOUGL. EX R. GRAH. =LITTLEFLOWER PENSTEMON	
PEPRB	PENSTEMON	PROCERUS	BRACHYANTHUS	(PENNELL) CRONQ. =	
PEPRF	PENSTEMON	PROCERUS	FORMOSUS	(A. NELS.) CRONQ. =	
PEPRT	PENSTEMON	PROCERUS	TOLMIEI	(HOOK.) CRONQ. =	
PEPR 2	PENSTEMON	PRUINOSUS		DOUGL. EX LINDL. =PRICKLEAF PENSTEMON	
PEPS	PENSTEMON	PSEUDOPROCERUS		RYDB. =	1
PEPU 2	PENSTEMON	PUMILUS		NUTT. =	
PERA 4	PENSTEMON	RADICOSUS		A. NELS. =MATROOT PENSTEMON	
PERA 2	PENSTEMON	RATTANI		GRAY =RATTAN PENSTEMON	
PERI	PENSTEMON	RICHARDSONII		DOUGL. EX LINDL. =RICHARDSON PENSTEMON	
PERID2	PENSTEMON	RICHARDSONII	DENTATUS	(KECK) CRONQ. =	
PERO	PENSTEMON	ROEZLII		REGEL =PLACER PENSTEMON	1
PERU	PENSTEMON	RUPICOLA		(PIPER) HOW. =CLIFF PENSTEMON	
PERY	PENSTEMON	RYDBERGII		A. NELS. =RYDBERG PENSTEMON	
PERYR	PENSTEMON	RYDBERGII	RYDBERGII	A. NELS. =RYDBERG PENSTEMON	
PERYV	PENSTEMON	RYDBERGII	VARIANS	(A. NELS.) CRONQ. =	
PESC	PENSTEMON	SCOULERI		LINDL. =SCOULER PENSTEMON	1

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PESE 3	PENSTEMON	SEORSUS		(A. NELS.) KECK =	
PESE	PENSTEMON	SERRULATUS		MENZIES EX SM. =COAST PENSTEMON	
PESP 3	PENSTEMON	SPATULATUS		PENNELL =	
PESP	PENSTEMON	SPECIOSUS		DOUGL. EX LINDL. =ROYAL PENSTEMON	
PESU	PENSTEMON	SUBGLABER		RYDB. =WASATCH PENSTEMON	
PESU 2	PENSTEMON	SUBSERRATUS		PENNELL =	
PETO	PENSTEMON	TOLMIEI		HOOK. =TOLMIE PENSTEMON	1
PETR	PENSTEMON	TRIPHYLLUS		DOUGL. =	
PEVA	PENSTEMON	VARIABILIS		SUKSD. =KLICKITAT PENSTEMON	1
PEVE	PENSTEMON	VENUSTUS		DOUGL. EX LINDL. =BLUEMOUNTAIN PENSTEMON	
PEVI	PENSTEMON	VIRENS		PENNELL EX RYDB. =GREEN PENSTEMON	
PEWA	PENSTEMON	WASHINGTONENSIS		KECK =	1
PEWH	PENSTEMON	WHIPPLEANUS		GRAY =	
PEWI	PENSTEMON	WILCOXII		RYDB. =WILCOX PENSTEMON	
PERID	PERIDERIDIA			REICHB. =FALSE CARAWAY; YAMPAH	
PEBO	PERIDERIDIA	BOLANDERI		(GRAY) NELS. & MACBR. =BOLANDER FALSE-CARAWAY	
PEGA 2	PERIDERIDIA	GAIRDNERI		(H. & A.) MATH. =YAMPA	
PEOR 2	PERIDERIDIA	OREGANA		(WATS.) MATH. =EPPAW	
PERSI	PERSICARIA			MEISSN. =	1
PETAL	PETALOSTEMUM			L. C. RICH. =PRAIRIECLOVER; PETALOSTEMUM	
PEOR 4	PETALOSTEMUM	ORNATUM		DOUGL. EX HOOK. =	
PETAS	PETASITES			GAERTN. =BUTTERBUR	
PEFR 2	PETASITES	FRIGIDUS		(L.) FRIES =	
PEFRN	PETASITES	FRIGIDUS	NIVALIS	(GREENE) CRONQ. =	
PEFRP	PETASITES	FRIGIDUS	PALMATUS	(AIT.) CRONQ. =	
PEFRT	PETASITES	FRIGIDUS	FRIGIDUS	(L.) FRIES =	

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PENI	PETASITES	NIVALIS		GREENE =	1
PEPA	PETASITES	PALMATUS		GRAY =PALMATE BUTTERBUR	1
PESA	PETASITES	SAGITTATUS		(BANKS) GRAY =	
PESP 2	PETASITES	SPECIOSA		NUTT. =	1
PECA 2	PETROPHYTUM	CAESPITOSUM		(NUTT.) RYDB. =	
PECI 2	PETROPHYTUM	CINERASCENS		(PIPER) RYDB. =	
PHSA	PHACA	SALSULA		FALL. =	2
PHACE	PHACELIA			JUSS. =PHACELIA	
PHAL 2	PHACELIA	ALPINA		RYDB. =	1
PHBI	PHACELIA	BICOLOR		TORR. EX WATS. =	
PHBO 2	PHACELIA	BOLANDERI		GRAY =	
PHCO 3	PHACELIA	CORYMBOSA		JEP. =	
PHFR	PHACELIA	FRANKLINII		(R. BR.) GRAY =	
PHGL 2	PHACELIA	GLANDULIFERA		PIPER =	
PHGL 3	PHACELIA	GLANDULOSA		NUTT. =	
PHHA	PHACELIA	HASTATA		DOUGL. EX LEHM. =	
PHHAA	PHACELIA	HASTATA	ALPINA	(RYDB.) CRONQ. =	
PHHAC	PHACELIA	HASTATA	COMPACTA	(BRAND) CRONQ. =	
PHHAH	PHACELIA	HASTATA	HASTATA	DOUGL. EX LEHM. =	
PHHAL2	PHACELIA	HASTATA	LEPTOSEPALA	(RYDB.) CRONQ. =	
PHHAL	PHACELIA	HASTATA	LEUCOPHYLLA	(TORR.) CRONQ. =WHITELEAVED PHACELI	
PHHE	PHACELIA	HETEROPHYLLA		PURSH =VARILEAF PHACELIA	
PHHU	PHACELIA	HUMILIS		T. & G. =	
PHID	PHACELIA	IDAHOENSIS		HENDERS. =IDAHO PHACELIA	
PHIN	PHACELIA	INCANA		BRAND =	
PHLE	PHACELIA	LEUCOPHYLLA		TORR. =	1

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PHLI	PHACELIA	LINEARIS		(PURSH) HOLZ.	=THREADLEAF PHACELIA	
PHLU	PHACELIA	LUTEA		(H. & A.) J. T. HOWELL	=	
PHLUC	PHACELIA	LUTEA	CALVA	CRONQ.	=	
PHLUP	PHACELIA	LUTEA	PURPURASCENS	J. T. HOWELL	=	
PHLUS	PHACELIA	LUTEA	SCOPULINA	(A. NELS.) CRONQ.	=	
PHMI	PHACELIA	MINUTISSIMA		HENDERSON	=	
PHNE	PHACELIA	NEMORALIS		GREENE	=	
PHPR 2	PHACELIA	PROCERA		GRAY	=	
PHRA	PHACELIA	RAMOSISSIMA		DOUGL. EX LEHM.	=BRANCHING PHACELIA	
PHRA 2	PHACELIA	RATTANII		GRAY	=RATTANS PHACELIA	
PHSE	PHACELIA	SERICEA		(GRAH.) GRAY	=SILKY PHACELIA	
PHTE	PHACELIA	TETRAMERA		J. T. HOWELL	=	
PHTH	PHACELIA	THERMALIS		GREENE	=	
PHVI	PHACELIA	VIRGATA		GREENE	=	1
PHLOX	PHLOX			L.	=PHLOX	
PHAC	PHLOX	ACULEATA		A. NELS.	=	
PHAD	PHLOX	ADSURGENS		TORR. EX GRAY	=PERIWINKLE PHLOX	
PHAU	PHLOX	AUSTROMONTANA		COV.	=DESERT PHLOX	
PHCA 2	PHLOX	CAESPITOSA		NUTT.	=TUFTED PHLOX	
PHCAC	PHLOX	CAESPITOSA	CONDENSATA	GRAY	=DWARF TUFTED PHLOX	
PHCO 2	PHLOX	COLUBRIA		WHERRY & CONST.	=	
PHDI	PHLOX	DIFFUSA		BENTH.	=SPREADING PHLOX	
PHDID	PHLOX	DIFFUSA	DIFFUSA	BENTH.	=SPREADING PHLOX	
PHDIL	PHLOX	DIFFUSA	LONGISTYLIS	(WHERRY) PECK	=	1
PHDO	PHLOX	DOUGLASII		HOOK.	=DOUGLAS PHLOX	1
PHDOR	PHLOX	DOUGLASII	RIGIDA	PECK	=THICKLEAF DOUGLAS PHLOX	1

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PHGR	PHLOX	GRACILIS		GREENE =	2
PHHE 2	PHLOX	HENDERSONII		(E. NELS.) CRONQ. =	
PHHO	PHLOX	HOODII		RICH. =HOODS PHLOX	
PHHOC	PHLOX	HOODII	CANESCENS	(T. & G.) PECK =	1
PHID 2	PHLOX	IDAHONIS		WHERRY =	
PHKE	PHLOX	KELSEYI		BRITT. =	
PHKEK	PHLOX	KELSEYI	KELSEYI	BRITT. =	
PHLI 2	PHLOX	LINEARIFOLIA		GRAY =	1
PHLO	PHLOX	LONGIFOLIA		NUTT. =LONGLEAF PHLOX	
PHLOC	PHLOX	LONGIFOLIA	CALVA	PECK =	1
PHLOH	PHLOX	LONGIFOLIA	HUMILIS	PECK =	1
PHMU	PHLOX	MULTIFLORA		A. NELS. =	
PHMU 2	PHLOX	MUSCIODES		NUTT. =	
PHPU	PHLOX	PULVINATA		(WHERRY) CRONQ. =	
PHSP	PHLOX	SPECIOSA		PURSH =SHOWY PHLOX	
PHSPL	PHLOX	SPECIOSA	LANCEOLATA	PECK =	1
PHSPN	PHLOX	SPECIOSA	NITIDA	SUKSD. =	1
PHSPO	PHLOX	SPECIOSA	OCCIDENTALIS	PECK =	1
PHVI 2	PHLOX	VIRIDIS		E. NELS. =	1
PHVI 3	PHLOX	VISCIDA		E. NELS. =STICKY PHLOX	
PHOEN	PHOENICAULIS			NUTT. =PHOENICAULIS; DAGGERPOD	
PHCH	PHOENICAULIS	CHEIRANTHOIDES		NUTT. =WALLFLOWER PHOENICAULIS	
PHCHC	PHOENICAULIS	CHEIRANTHOIDES	CHEIRANTHOIDES	NUTT. =WALLFLOWER PHOENICAULIS	
PHCHL	PHOENICAULIS	CHEIRANTHOIDES	LANUGINOSA	(WATS.) ROLL. =	
PHYSA2	PHYSALIS			L. =GROUND-CHERRY	
PHLO 2	PHYSALIS	LONGIFOLIA		NUTT. =	

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PHPR 3	PHYSALIS	PRUINOSA		L.	=	
PHYSA	PHYSARIA			GRAY	=TWINPOD	
PHAL 3	PHYSARIA	ALPESTRIS		SUKSD.	=	
PHDI 2	PHYSARIA	DIDYMOCARPA		(HOOK.) GRAY	=COMMON TWINPOD	
PHGE	PHYSARIA	GEYERI		(HOOK.) GRAY	=	
PHOR	PHYSARIA	OREGANA		WATS.	=	
PILUL	PILULARIA			L.	=PILLWORT	
PIMPI	PIMPINELLA			L.	=PIMPINELLA	
PISA	PIMPINELLA	SAXIFRAGA		L.	=	
PINGU	PINGUICULA			L.	=BUTTERWORT	
PIVU	PINGUICULA	VULGARIS		L.	=COMMON BUTTERWORT	
PITYR	PITYROGRAMMA			LINK	=GOLDFERN	
PITR	PITYROGRAMMA	TRIANGULARIS		(KAUF.) MAXON	=CALIFORNIA GOLDFERN	
PLAGI	PLAGIOBOTHRYS			FISCH.	=POPCORNFLOWER	
PLCU	PLAGIOBOTHRYS	CUSICKII		JOHNST.	=	1
PLFI	PLAGIOBOTHRYS	FIGURATUS		(PIPER) JOHNST. EX PECK	=	
PLHA	PLAGIOBOTHRYS	HARKNESSII		(GREENE) NELS. & MACBR.	=	
PLHI	PLAGIOBOTHRYS	HISPIDULUS		JOHNST.	=	1
PLHI 2	PLAGIOBOTHRYS	HISPIDUS		GRAY	=	
PLLE	PLAGIOBOTHRYS	LEPTOCLADUS		(GREENE) JOHNST.	=	
PLMO	PLAGIOBOTHRYS	MOLLIS		(GRAY) JOHNST.	=	
PLNO	PLAGIOBOTHRYS	NOTHOFULVUS		GRAY	=	
PLSC 2	PLAGIOBOTHRYS	SCOULERI		(H. & A.) JOHNST.	=SCOULER POPCORNFLOWER	
PLSCP	PLAGIOBOTHRYS	SCOULERI	PENICILLATUS	(GREENE) CRONQ.	=	
PLSCS	PLAGIOBOTHRYS	SCOULERI	SCOULERI	(H. & A.) JOHNST.	=SCOULER POPCORNFLOWER	
PLTE	PLAGIOBOTHRYS	TENELLUS		(NUTT.) GRAY	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
PLTE 2	PLAGIOBOTHRYS	TENER		(GREENE) JOHNST.	=	
PLANT	PLANTAGO			L.	=PLANTAIN	
PLAR	PLANTAGO	ARISTATA		MICHX.	=	
PLAS	PLANTAGO	ASIATICA		L.	=ASIATIC PLANTAIN	
PLEL	PLANTAGO	ELONGATA		PURSH	=	
PLER	PLANTAGO	ERIOPODA		TORR.	=	
PLGA	PLANTAGO	GALEATTIANA		DCNE.	=BEAK PLANTAIN	
PLHI 3	PLANTAGO	HIRTELLA		H. B. K.	=	
PLLA	PLANTAGO	LANCEOLATA		L.	=BUCKHCRN PLANTAIN	
PLMA 4	PLANTAGO	MACROCARPA		CHAM. & SCHLECHT.	=	
PLMA	PLANTAGO	MAJOR		L.	=RIPPLESEED PLANTAIN	
PLMA 2	PLANTAGO	MARITIMA		L.	=EUROPEAN SEASIDE PLANTAIN	
PLPA	PLANTAGO	PATAGONICA		JACQ.	=PATAGONIA INDIANWHEAT	
PLPU	PLANTAGO	PURSHII		ROEM. & SCHULT.	=PLANTAIN	1
PLATY	PLATYSPERMUM			HOOK.	=	2
PLSC	PLATYSPERMUM	SCAPIGERUM		HOOK.	=	2
PLECT	PLECTRITIS			DC.	=PLECTRITIS	
PLCI	PLECTRITIS	CILIOSA		(GREENE) JEPS.	=	
PLCO	PLECTRITIS	CONGESTA		(LINDL.) DC.	=	
PLMA 3	PLECTRITIS	MACROCERA		T. & G.	=LONGHCRN PLECTRITIS	
PLEUR2	PLEURICOSPORA			GRAY	=SIERRA-SAP; FRINGEC-PINESAP	
PLFI 2	PLEURICOSPORA	FIMBRIOLATA		GRAY	=	
POLAN	POLANISIA			RAF.	=CLAMMYWEED	
POTR 4	POLANISIA	TRACHYSPERMA		T. & G.	=	
POLEM	POLEMONIUM			L.	=PCLEMONIUM; JACOBS LADDER	
POCA 9	POLEMONIUM	CALIFORNICUM		EAST.	=CALIFCRNIA POLEMCNIUM	

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POCA 2	POLEMONIUM	CARNEUM		GRAY =SALMON POLEMONIUM	
POEL	POLEMONIUM	ELEGANS		GREENE =	
POMI	POLEMONIUM	MICRANTHUM		BENTH. =LITTLEBELLS POLEMONIUM	
POOC	POLEMONIUM	OCCIDENTALE		GREENE =WESTERN POLEMONIUM	
POPU	POLEMONIUM	PULCHERRIMUM		HOOK. =SKUNKLEAF POLEMONIUM	
POPUC	POLEMONIUM	PULCHERRIMUM	CALYCINUM	(EASTW.) BRAND =SKUNKLEAF POLEMONIUM	
POPUP	POLEMONIUM	PULCHERRIMUM	PULCHERRIMUM	HOOK. =SKUNKLEAF POLEMONIUM	
POVI	POLEMONIUM	VISCOSUM		NUTT. =STICKY POLEMONIUM	
POLYC	POLYCTENIUM			GREENE =COMBLEAF; POLYCTENIUM	
POFR 2	POLYCTENIUM	FREMONTII		(WATS.) GREENE =	
POCA 8	POLYGALA	CALIFORNICA		NUTT. =CALIFORNIA MILKWORT	
POLYG	POLYGONUM			L. =KNOTWEED	
POAC	POLYGONUM	ACHOREUM		BLAKE =	
POAM 2	POLYGONUM	AMPHIBIUM		L. =WATER LADYSTHUMB	
POAMS	POLYGONUM	AMPHIBIUM	STIPULACEUM	COLEMAN =	
POAU	POLYGONUM	AUSTINIAE		GREENE =	
POAV	POLYGONUM	AVICULARE		L. =PROSTRATE KNOTWEED	
POBI	POLYGONUM	BISTORTOIDES		PURSH =AMERICAN BISTORT	
POBIH	POLYGONUM	BISTORTOIDES	HARTWRIGHTII	GRAY =	1
POCA 6	POLYGONUM	CALIFORNICUM		MEISN. =	
POCA 5	POLYGONUM	CASCADENSE		BAKER =	
POCO 4	POLYGONUM	COCCINEUM		MUHL. =	
POCO 5	POLYGONUM	CONFERTIFLORUM		NUTT. EX PIPER =	
POCO 2	POLYGONUM	CONVOLVULUS		L. =DULLSEED CORNBIND	
POCU 2	POLYGONUM	CUSPIDATUM		SIEB. & ZUCC. =	
PODO	POLYGONUM	DOUGLASII		GREENE =DOUGLAS KNOTWEED	

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POER	POLYGONUM	ERECTUM		L.	=ERECT KNOTWEED	
POFO	POLYGONUM	FOWLERI		ROBINS.	=	
POHE	POLYGONUM	HETEROSEPALUM		PECK & OWNBEY	=	
POHY	POLYGONUM	HYDROPIPER		L.	=MARSHPEPPER SMARTWEED	
POHY 2	POLYGONUM	HYDROPIPEROIDES		MICHX.	=	
POKE	POLYGONUM	KELLOGGII		GREENE	=	
POLA	POLYGONUM	LAPATHIFOLIUM		L.	=CURLTOP LADYSTHUMB	
POMA 2	POLYGONUM	MAJUS		(MEISN.) PIPER	=	
POMI 2	POLYGONUM	MINIMUM		WATS.	=BROADLEAF KNOTWEED	
POMO 2	POLYGONUM	MONTANUM		GREENE	=	1
PONA	POLYGONUM	NATANS		EAT.	=FLOATING LADYSTHUMB	1
PONE 4	POLYGONUM	NEWBERRYI		SMALL	=NEWBERRY FLEECEFLOWER	
PONU	POLYGONUM	NUDUM		DULAC.	=	
PONU 2	POLYGONUM	NUTTALLII		SMALL	=	
POPA 2	POLYGONUM	PARONYCHIA		CHAM. & SCHLECHT.	=NAILWORT KNOTWEED	
POPA 4	POLYGONUM	PARRYI		GREENE	=	
POPE	POLYGONUM	PERSICARIA		L.	=SPOTTED LADYSTHUMB	
POPH	POLYGONUM	PHYTOLACCAEFOLIUM		MEISN. EX SMALL	=POKEWEED FLEECEFLOWER	
POPO	POLYGONUM	POLYGALOIDES		MEISN.	=POLYGALA KNOTWEED	
POPO 2	POLYGONUM	POLYSTACHYUM		WALL.	=	
POPU 4	POLYGONUM	PUNCTATUM		ELL.	=	
PORA	POLYGONUM	RAMOSISSIMUM		MICHX.	=	
POSA 2	POLYGONUM	SACHALINENSE		F. SCHMIDT EX MAXIM.	=	
POSA	POLYGONUM	SAWATCHENSE		SMALL	=SAWATCH KNOTWEED	
POSC 2	POLYGONUM	SCANDENS		L.	=HEDGE CORNBIND	
POSP	POLYGONUM	SPERGULARIAEFORME		MEISN. EX SMALL	=	

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POVI 2	POLYGONUM	VIVIPARUM		L. =VIVIPAROUS BISTORT	
POWA	POLYGONUM	WATSONI		SMALL =	
POLYP	POLYPODIUM			L. =LICORICE FERN; POLYPODY FERN	
POGL 4	POLYPODIUM	GLYCYRRHIZA		D. C. EAT. =LICORICEFERN	
POHE 2	POLYPODIUM	HESPERIUM		MAXON =	
POSC 4	POLYPODIUM	SCOULERI		HOOK. & GREV. =	
POLYS	POLYSTICHUM			ROTH =HOLLYFERN; SWORDFERN	
POAN 3	POLYSTICHUM	ANDERSONII		HOPKINS =	
POCA 7	POLYSTICHUM	CALIFORNICUM		(D. C. EAT.) DIELS =	
POKR	POLYSTICHUM	KRUCKEBERGII		WAGNER =	
POLO 2	POLYSTICHUM	LONCHITIS		(L.) ROTH =MOUNTAIN HOLLYFERN	
POMO 3	POLYSTICHUM	MOHRIOIDES		(BORY) PRESL =	
POMU	POLYSTICHUM	MUNITUM		(KAULF.) PRESL. =WESTERN SWORDFERN	
POMUI	POLYSTICHUM	MUNITUM	IMBRICANS	(D. C. EAT.) MAXON =IMBRICATED SWORDFERN	
POSC 3	POLYSTICHUM	SCOPULINUM		(D. C. EAT.) MAXON =EATON HOLLYFERN	
POOR	PONISTA	OREGONENSIS		RAF. =	2
PORTE	PORTERELLA			TORR. =PORTERELLA	
POCA 4	PORTERELLA	CARNOSULA		(H. & A.) TORR. =	
PORTU	PORTULACA			L. =PORTULACA	
POOL	PORTULACA	OLERACEA		L. =COMMON PURSLANE	
POTAM	POTAMOGETON			L. =PONDWEED	
POAL 3	POTAMOGETON	ALPINUS		BALBIS =	
POALT	POTAMOGETON	ALPINUS	TENUIFOLIUS	(RAF.) OGDEN =	
POAM 3	POTAMOGETON	AMPLIFOLIUS		TUCKERMAN =	
POBE	POTAMOGETON	BERCHTOLDII		FIEB. =	
POCR	POTAMOGETON	CRISPUS		L. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
PODI 2	POTAMOGETON	DIVERSIFOLIUS		RAF. =	
POEP 2	POTAMOGETON	EFIHYDRUS		RAF. =RIBBONLEAF PONDWEEC	
POFI 2	POTAMOGETON	FIBRILLOSUS		FERN. =	
POFI 3	POTAMOGETON	FILIFORMIS		PERS. =	
POFO 2	POTAMOGETON	FCLIOSUS		RAF. =	
POFOF	POTAMOGETON	FCLIOSUS	FOLIOSUS	RAF. =	
POFR 3	POTAMOGETON	FRIESII		RUPR. =	
POGR 3	POTAMOGETON	GRAMINEUS		L. =	
POIL	POTAMOGETON	ILLINOENSIS		MORONG =	
PONA 2	POTAMOGETON	NATANS		L. =FLOATINGLEAF PONDWEED	
PONO 2	POTAMOGETON	NODOSUS		POIR. =	
POPA 5	POTAMOGETON	PAUCIFLORUS		PURSH =	
POPE 2	POTAMOGETON	PECTINATUS		L. =	
POPR 3	POTAMOGETON	PRAELONGUS		WULF. =	
POPU 5	POTAMOGETON	PLSILLUS		L. =	
PORI 2	POTAMOGETON	RICHARDSONII		(BENNETT) RYDB. =	
PORO	POTAMOGETON	ROBBINSII		OAKES =	
POVA 3	POTAMOGETON	VAGINATUS		TURCZ. =	
POZO	POTAMOGETON	ZOSTERIFORMIS		FERN. =	
POTEN	POTENTILLA			L. =CINQUEFOIL; FIVE-FINGER	
POAN 4	POTENTILLA	ANSERINA		L. =	
POANG	POTENTILLA	ANSERINA	GRANDIS	T. & G. =	1
POAR	POTENTILLA	ARGENTEA		L. =SILVER CINQUEFCIL	
POARC	POTENTILLA	ARGUTA	CONVALLARIA	(RYDB.) T. WOLF =	
POBA	POTENTILLA	BAKERI		RYDB. =BAKER CINQUEFOIL	
POBI 2	POTENTILLA	BIENNIS		GREENE =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
POBL	POTENTILLA	BLASCHKEANA		TUREZ. EX LEHM. =	1
POBR	POTENTILLA	BREVIFOLIA		NUTT. =	
POBR 2	POTENTILLA	BREWERI		WATS. =	
POCA 3	POTENTILLA	CASCADENSIS		RYDB. =	1
POCO 3	POTENTILLA	CORYMBOSA		FEDDE =	1
PODI	POTENTILLA	DIVERSIFOLIA		LEHM. =VARILEAF CINQUEFOIL	
PODR	POTENTILLA	DRUMMONDII		LEHM. =DRUMMOND CINQUEFOIL	
POET	POTENTILLA	ETOMENTOSA		RYDB. =	1
POFA	POTENTILLA	FASTIGIATA		HOOK. EX T. & G. =	1
POFI	POTENTILLA	FISSA		NUTT. =BIGFLOWER CINQUEFOIL	
POFL 2	POTENTILLA	FLABELLIFOLIA		HOOK. EX T. & G. =FANLEAF CINQUEFOIL	
POFL	POTENTILLA	FLABELLIFORMIS		LEHM. =	1
POGL 3	POTENTILLA	GLABRATA		LEHM. =	1
POGL	POTENTILLA	GLANDULOSA		LINDL. =GLAND CINQUEFOIL	
POGLC	POTENTILLA	GLANDULOSA	CAMPANULATA	C. L. HITCHC. =	
POGLG	POTENTILLA	GLANDULOSA	GLANDULOSA	LINDL. =	
POGLI	POTENTILLA	GLANDULOSA	INTERMEDIA	(RYDB.) C. L. HITCHC. =	
POGLN	POTENTILLA	GLANDULOSA	NEVADENSIS	WATS. =	
POGLP	POTENTILLA	GLANDULOSA	PSEUDORUPESTRIS	(RYDB.) BREIT =	
POGLR	POTENTILLA	GLANDULOSA	REFLEXA	GREENE =	
POGL 2	POTENTILLA	GLAUCOPHYLLA		LEHM. =BLUELEAF CINQUEFOIL	1
POGR	POTENTILLA	GRACILIS		DOUGL. EX HOOK. =NORTHWEST CINQUEFOIL	
POGRB	POTENTILLA	GRACILIS	BRUNNESCENS	(RYDB.) C. L. HITCHC. =	
POGRF	POTENTILLA	GRACILIS	FLABELLIFORMIS	(LEHM.) NUTT. EX T. & G. =	
POGRG	POTENTILLA	GRACILIS	GLABRATA	(LEHM.) C. L. HITCHC. =NUTTAL CINQUEFOIL	
POGRG2	POTENTILLA	GRACILIS	GRACILIS	DOUGL. EX HOOK. =NORTHWEST CINQUEFOIL	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
POGRN	POTENTILLA	GRACILIS	NUTTALLII	SHELC.	=	1
POGRP	POTENTILLA	GRACILIS	PERMOLLIS	(RYDB.) C. L. HITCHC.	=	
POGRP2	POTENTILLA	GRACILIS	PULCHERRIMA	(LEHM.) FERN.	=	
PONE 3	POTENTILLA	NEWBERRYI		GRAY	=	
PONI	POTENTILLA	NIVEA		L.	=SNOWY CINQUEFOIL	
PONO	POTENTILLA	NORVEGICA		L.	=NORWEGIAN CINQUEFOIL	
PONOH	POTENTILLA	NORVEGICA	HIRSUTA	LEHM.	=HAIRY NORWEGIAN CINQUEFOIL	1
POOV	POTENTILLA	OVINA		MACOUN	=	
POPA 8	POTENTILLA	PACIFICA		HOWELL	=	
POPA 3	POTENTILLA	PALUSTRIS		(L.) SCOP.	=MARSH CINQUEFOIL	
POPA 9	POTENTILLA	PARADOXA		NUTT.	=	
POPE 4	POTENTILLA	PENSYLVANICA		L.	=	
POPE 3	POTENTILLA	PERMOLLIS		RYDB.	=	1
POPU 3	POTENTILLA	PULCHERRIMA		LEHM.	=BEAUTY CINQUEFOIL	1
POPU 2	POTENTILLA	PUMILA		FEDDE	=PETTY CINQUEFOIL	1
POQU	POTENTILLA	QUINQUEFOLIA		RYDB.	=	
PORE 2	POTENTILLA	RECTA		L.	=	
PORH	POTENTILLA	RHOMBOIDEA		RYDB.	=	1
PORI	POTENTILLA	RIVALIS		NUTT.	=BROOK CINQUEFOIL	
POVA 2	POTENTILLA	VALIDA		GREENE	=	1
POVI 4	POTENTILLA	VILLOSA		PALL. EX PURSH	=	
POVIP	POTENTILLA	VILLOSA	PARVIFLORA	C. L. HITCHC.	=	
POVI 3	POTENTILLA	VIRIDESCENS		RYDB.	=	1
PRENA	PRENANTHES			L.	=RATTLESNAKEROOT	
PRAL	PRENANTHES	ALATA		(HOOK.) D. DIETR.	=	
PRIMU	PRIMULA			L.	=PRIMROSE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
PRCU	PRIMULA	CUSICKIANA		GRAY =	
PRIN	PRIMULA	INCANA		M. E. JONES =	
PRPA	PRIMULA	PARRYI		GRAY =	
PRUNE	PRUNELLA			L. =SELFHEAL	
PRVU	PRUNELLA	VULGARIS		L. =COMMON SELFHEAL	
PSILO	PSILOCARPHUS			NUTT. =WOOLY-HEADS	
PSBR	PSILOCARPHUS	BREVISSIMUS		NUTT. =	
PSEL	PSILOCARPHUS	ELATIOR		GRAY =	
PSOR	PSILOCARPHUS	OREGONUS		NUTT. =	
PSTE	PSILOCARPHUS	TENELLUS		NUTT. =	
PSORA	PSORALEA			L. =SCURFPEA; PSORALEA	
PSLA	PSORALEA	LANCEOLATA		PURSH =LEMON SCURFPEA	
PSPH	PSORALEA	PHYSODES		DOUGL. EX HOOK. =CALIFORNIATEA SCURFPEA	
PTERE	PTERETIS			RAF. =PTERETIS	2
PTSP	PTERETIS	SPICANT		=	2
PTERI	PTERIDIUM			SCOP. =BRACKEN; BRAKE FERN	
PTAQ	PTERIDIUM	AQUILINUM		(L.) KUHN IN VON DER DECKEN =	
PTAQL	PTERIDIUM	AQUILINUM	LANUGINOSUM	(BONG.) FERN. =	
PTAQP	PTERIDIUM	AQUILINUM	PUBESCENS	UNDERW. =WESTERN BRACKEN FERN	
PTERO	PTEROSPORA			NUTT. =PINEDROPS	
PTAN	PTEROSPORA	ANDROMEDEA		NUTT. =WOODLAND PINEDROPS	
PTERY	PTERYXIA			NUTT. =	2
PTTEF	PTERYXIA	TEREBINTHINA	FOENICULACEA	MATHIAS =	2
PYROL	PYROLA			L. =PYROLA	
PYAP	PYROLA	APHYLLA		SMITH =LEAFLESS PYROLA	
PYAS	PYROLA	ASARIFOLIA		MICHX. =ALPINE PYROLA	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME ALTHORSHIP COMMON NAME	S C
PYASI	PYROLA	ASARIFOLIA	INCARNATA	FERN. =	
PYCH	PYROLA	CHLORANTHA		SW. =GREEN PYROLA	1
PYDE	PYROLA	DENTATA		SMITH =TOOTHLEAF PYROLA	
PYEL	PYROLA	ELLIPTICA		NUTT. =	
PYMI	PYROLA	MINOR		L. =SNOWLINE PYROLA	
PYPA	PYROLA	PALLIDA		GREENE =	1
PYPI	PYROLA	PICTA		SMITH =WHITEVEIN PYROLA	
PYRO	PYROLA	ROTUNDIFOLIA		L. =	1
PYSE	PYROLA	SECUNDA		L. =SIDEBELLS PYROLA	
PYUN	PYROLA	UNIFLORA		L. =WOODNYMPH PYROLA	
PYVI	PYROLA	VIRENS		SCHWEIGG. =GREEN PYROLA	
QUAZ	QUAMASIA	AZUREA		HELLER =	1
RAILL	RAILLARDELLA			GRAY =RAILLARDELLA	
RAAR	RAILLARDELLA	ARGENTEA		(GRAY) GRAY =	
RASC 2	RAILLARDELLA	SCAPOSA		GRAY =	
RAINI	RAINIERA			GREENE =	2
RAST	RAINIERA	STRICTA		GREENE =	2
RANUN	RANUNCULUS			L. =BUTTERCUP	
RAAB	RANUNCULUS	ABORTIVUS		L. =	
RAAC 2	RANUNCULUS	ACRIFORMIS		GRAY =	
RAACM	RANUNCULUS	ACRIFORMIS	MONTANENSIS	(RYDB.) BENSON =	
RAAC	RANUNCULUS	ACRIS		L. =	
RAAL	RANUNCULUS	ALISMAEFOLIUS		GEYER EX BENTH. =PLANTAINLEAF BUTTERCUP	
RAALA2	RANUNCULUS	ALISMAEFOLIUS	ALISMAEFOLIUS	GEYER EX BENTH. =PLANTAINLEAF BUTTERCUP	
RAALA	RANUNCULUS	ALISMAEFOLIUS	ALISMELLUS	GRAY =DWARF PLANTAINLEAF BUTTERCUP	
RAAN	RANUNCULUS	ANDERSONII		GRAY =ANDERSON BUTTERCUP	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
RAAQ	RANUNCULUS	AQUATILIS		L. =WATERCROWFOOT BUTTERCUP	
RAAQA	RANUNCULUS	AQUATILIS	AQUATILIS	L. =WATERCROWFOOT BUTTERCUP	
RAAQC	RANUNCULUS	AQUATILIS	CAPILLACEUS	(THUILL.) DC. =HAIRLEAF WATERCROWFOOT BUTTERCUP	
RAAQL	RANUNCULUS	AQUATILIS	LONGIROSTRIS	LAWS. =	1
RAAR 2	RANUNCULUS	ARVENSIS		L. =	
RABO	RANUNCULUS	BONGARDII		GREENE =BONGARD BUTTERCUP	1
RABU	RANUNCULUS	BULBOSUS		L. =	
RACA	RANUNCULUS	CALIFORNICUS		BENTH. =CALIFORNIA BUTTERCUP	
RACA 2	RANUNCULUS	CARDIOPHYLLUS		HOOK. =	
RACO	RANUNCULUS	COOLEYAE		VASEY & ROSE =	
RACY	RANUNCULUS	CYMBALARIA		PURSH =SHORE BUTTERCUP	
RACYS	RANUNCULUS	CYMBALARIA	SAXIMONTANUS	FERN. =SHORE BUTTERCUP	
RADO	RANUNCULUS	DOUGLASII		HOWELL =	1
RAES	RANUNCULUS	ESCHSCHOLTZII		SCHLECHT. =ESCHSCHOLTZ BUTTERCUP	
RAFL	RANUNCULUS	FLABELLARIS		RAF. =	
RAFL 2	RANUNCULUS	FLAMMULA		L. =	
RAFLU	RANUNCULUS	FLAMMULA	UNALASCHENSIS	LEDEB. =	
RAGL	RANUNCULUS	GLABERRIMUS		HOOK. =SAGEBRUSH BUTTERCUP	
RAGM	RANUNCULUS	GMELINII		DC. =	
RAGO	RANUNCULUS	GORMANII		GREENE =	
RAHE	RANUNCULUS	HEBECARPUS		H. & A. =	
RAIN	RANUNCULUS	INAMOENUS		GREENE =	
RAIN 2	RANUNCULUS	INTERTEXTUS		GREENE =	1
RALO	RANUNCULUS	LOBBII		(HIERN) GRAY =	
RALO 2	RANUNCULUS	LONGIROSTRIS		GODR. =	
RAMA	RANUNCULUS	MACOUNII		BRITT. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
RAMU	RANUNCULUS	MURICATUS		L. =	
RANA	RANUNCULUS	NATANS		C. A. MEYER =	
RANAI	RANUNCULUS	NATANS	INTERTEXTUS	(GREENE) BENSON =	
RAOC	RANUNCULUS	OCCIDENTALIS		NUTT. =WESTERN BUTTERCUP	
RAOR 2	RANUNCULUS	ORESTERUS		BENSON =	
RAOR	RANUNCULUS	ORTHORHYNCHUS		HOOK. =STRAIGHTBEAK BUTTERCUP	
RAORO	RANUNCULUS	ORTHORHYNCHUS	ORTHORHYNCHUS	HOOK. =STRAIGHTBEAK BUTTERCUP	
RAORP	RANUNCULUS	ORTHORHYNCHUS	PLATYPHYLLUS	GRAY =GREAT STRAIGHTBEAK BUTTERCUP	
RAPE	RANUNCULUS	PENSYLVANICUS		L. =	
RAPO	RANUNCULUS	POPULAGO		GREENE =	
RAPU	RANUNCULUS	PURSHII		RICHARDS. =	1
RARE 3	RANUNCULUS	RECONDITUS		NELS. & MACBR. =	
RARE	RANUNCULUS	REPENS		L. =CREEPING BUTTERCUP	
RARE 2	RANUNCULUS	REPTANS		L. =	1
RASC	RANUNCULUS	SCELERATUS		L. =BLISTER BUTTERCUP	
RASU 2	RANUNCULUS	SUBRIGIDUS		W. DREW =	
RASU	RANUNCULUS	SUKSDORFII		GRAY =SUKSDORF BUTTERCUP	
RATE	RANUNCULUS	TESTICULATUS		CRANTZ =	
RAUN	RANUNCULUS	UNALASCHENSIS		BESS. EX LEDEB. =	1
RAUN 2	RANUNCULUS	UNCINATUS		D. DON =	
RAUNP	RANUNCULUS	UNCINATUS	PARVIFLORUS	(TORR.) L. BENSON =	
RAVE	RANUNCULUS	VERECUNDUS		ROBINS. =	
RAZOU	RAZOUMOFSKYA			JUSS. =	2
RHINA	RHINANTHUS			L. =RATTLE; RATTLE-BOX	
RHCR	RHINANTHUS	CRISTA-GALLI		L. =	
RHYSO	RHYSOPTERUS			COULT. & ROSE =CORKSEED; RHYSOPTERUS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
RHPL	RHYSOPTERUS	PLURIJUGUS		COULT. & ROSE =	
RIGIO	RIGIOPAPPUS			GRAY =WIREWEED	
RILE	RIGIOPAPPUS	LEPTOCLADUS		GRAY =BRISTLEHEAD	
ROMAN	ROMANZOFFIA			CHAM. =MISTMAIDEN	
ROSI	ROMANZOFFIA	SITCHENSIS		BONG. =SITKA MISTMAIDEN	
ROSU	ROMANZOFFIA	SUKSDORFII		GREENE =	
ROTR	ROMANZOFFIA	TRACYI		JEPS. =	
RORIP	RORIPPA			SCOP. =CRESS	
ROCA	RORIPPA	CALYCINA		(ENGELM.) RYDB. =	
ROCU	RORIPPA	CURVISILIQUA		(HOOK.) BESSEY EX BRITT. =	
ROIS	RORIPPA	ISLANDICA		(OED.) BORBAS =	
ROISI	RORIPPA	ISLANDICA	ISLANDICA	(OED.) BORBAS =	
ROLY	RORIPPA	LYRATA		GREENE =	1
RONA	RORIPPA	NASTURTIUM-AQUATICUM		(L.) SCHINZ & THELL. =WATERCRESS	
ROOB	RORIPPA	OBTUSA		(NUTT.) BRITT. =	
ROSI 2	RORIPPA	SINUATA		(NUTT.) HITCHC. =	
ROSY	RORIPPA	SYLVESTRIS		(L.) BESSER =	
RUDBE	RUDBECKIA			L. =CONEFLOWER	
RUAL	RUDBECKIA	ALPICOLA		PIPER =	1
RUHI	RUDBECKIA	HIRTA		L. =BLACKEYEDSUSAN	
RULA 3	RUDBECKIA	LACINIATA		L. =	
RUOC	RUDBECKIA	OCCIDENTALIS		NUTT. =BLACKHEAD	
RUOCA	RUDBECKIA	OCCIDENTALIS	ALPICOLA	(PIPER) CRONQ. =	
RUMEX	RUMEX			L. =DOCK; SORREL	
RUAC 2	RUMEX	ACETOSA		L. =	
RUAC	RUMEX	ACETOSELLA		L. =SHEEP SORREL	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
RUCO	RUMEX	CONGLOMERATUS		MURR. =	
RUCR	RUMEX	CRISPUS		L. =CURLY DOCK	
RUCU	RUMEX	CUNEIFOLIUS		CAMPD. =	
RUMA 2	RUMEX	MARITIMUS		L. =	
RUME	RUMEX	MEXICANUS		MEISN. =MEXICAN DOCK	
RUOB	RUMEX	OBTUSIFOLIUS		L. =BITTER DOCK	
RUOC 2	RUMEX	OCCIDENTALIS		WATS. =WESTERN DOCK	
RUPA 3	RUMEX	PATIENTIA		L. =	
RUPA 2	RUMEX	PAUCIFOLIUS		NUTT. =MOUNTAIN SORREL	
RUPE 2	RUMEX	PERSICARIOIDES		L. =	
RUPU	RUMEX	PULCHER		L. =	
RUSA	RUMEX	SALICIFOLIUS		WEINM. =WILLOW DOCK	
RUSA 2	RUMEX	SANGUINEUS		L. =	
RUVE	RUMEX	VENOSUS		PURSH =VEINY DOCK	
SAGIN	SAGINA			L. =PEARLWORT	
SAAP	SAGINA	APETALA		L. =	
SAOC 2	SAGINA	OCCIDENTALIS		WATS. =	
SAPR	SAGINA	PROCUMBENS		L. =	
SASA	SAGINA	SAGINOIDES		(L.) BRITT. =ARCTIC PEARLWORT	
SAGIT	SAGITTARIA			L. =ARROWHEAD	
SAAR	SAGITTARIA	ARIFOLIA		NUTT. EX J. G. SM. =	1
SACU	SAGITTARIA	CUNEATA		SHELD. =	
SALA	SAGITTARIA	LATIFOLIA		WILLD. =COMMON ARROWHEAD	
SAMO 3	SAGITTARIA	MONTEVIDENSIS		CHAM. & SCHLECHT. =	
SALIC	SALICORNIA			L. =SAMPHIRE; GLASSWORT	
SAEU	SALICORNIA	EUROPAEA		L. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
SARU 2	SALICORNIA	RUBRA		A. NELS. =	
SAVI	SALICORNIA	VIRGINICA		L. =	
SALSO	SALSOLA			L. =RUSSIANTHISTLE	
SAKA	SALSOLA	KALI		L. =	
SAKAT	SALSOLA	KALI	TENUIFOLIA	TAUSCH =COMMON RUSSIANTHISTLE	1
SALVI	SALVIA			L. =SAGE	
SAAE 2	SALVIA	AETHIOPIS		L. =MEDITERRANEAN SAGE	
SANGU	SANGUISORBA			L. =BURNET	
SAAN	SANGUISORBA	ANNUA		NUTT. =PRAIRIE BURNET	1
SACA 3	SANGUISORBA	CANADENSIS		L. =AMERICAN BURNET	
SAME 4	SANGUISORBA	MENZIESII		RYDB. =	
SAMI	SANGUISORBA	MICROCEPHALA		PRESL. =	1
SAMI 2	SANGUISORBA	MINOR		SCOP. =SMALL BURNET	
SAOC	SANGUISORBA	OCCIDENTALIS		NUTT. =	
SAOF	SANGUISORBA	OFFICINALIS		L. =GARDEN BURNET	
SASI	SANGUISORBA	SITCHENSIS		C. A. MEY. =SITKA BURNET	
SANIC	SANICULA			L. =SANICLE	
SAAR 2	SANICULA	ARCTOPOIDES		H. & A. =	
SABI	SANICULA	BIPINNATIFIDA		DOUGL. =POISON SANICLE	
SACR	SANICULA	CRASSICAULIS		POEPP. EX DC. =	
SAGR	SANICULA	GRAVEOLENS		POEPP. EX DC. =	
SAMA 3	SANICULA	MARILANDICA		L. =	
SASE	SANICULA	SEPTENTRIONALIS		GREENE =	1
SAPON	SAPONARIA			L. =SOAPWORT	
SAOF 2	SAPONARIA	OFFICINALIS		L. =BOUNCINGBET	
SAVA	SAPONARIA	VACCARIA		L. =COW SOAPWORT	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
SASA 2	SARCODES	SANGUINEA		TORR. =SNOW PLANT	
SATUR	SATUREJA			L. =SAVORY; YERBA BUENA	
SADO	SATUREJA	DOUGLASII		(BENTH.) BRIQ. =	
SAUSS	SAUSSUREA			DC. =SAUSSUREA	
SAAM	SAUSSUREA	AMERICANA		EAT. =	
SAXIF	SAXIFRAGA			L. =SAXIFRAGE	
SAAD	SAXIFRAGA	ADSCENDENS		L. =	
SAADO	SAXIFRAGA	ADSCENDENS	OREONGENSIS	(RAF.) BREIT. =	
SAAE	SAXIFRAGA	AESTIVALIS		F. & M. =SUMMER SAXIFRAGE	1
SAAR 4	SAXIFRAGA	ARGUTA		D. DON =BROOK SAXIFRAGE	
SAAU	SAXIFRAGA	AUSTROMONTANA		WIEG. =	1
SABO	SAXIFRAGA	BONGARDII		PRESL. =BONGARD SAXIFRAGE	
SABR	SAXIFRAGA	BRONCHIALIS		L. =	
SABRA	SAXIFRAGA	BRONCHIALIS	AUSTROMONTANA	(WIEG.) G. N. JONES =	
SACA 4	SAXIFRAGA	CAESPITOSA		L. =	
SACE 2	SAXIFRAGA	CERNUA		L. =	
SACH	SAXIFRAGA	CHERLERIOIDES		D. DON =	
SACO	SAXIFRAGA	COLUMBIANA		PIPER =COLUMBIAN SAXIFRAGE	1
SADE	SAXIFRAGA	DEBILIS		ENGELM. EX GRAY =	
SAFE	SAXIFRAGA	FERRUGINEA		GRAH. =	
SAFR	SAXIFRAGA	FRAGOSA		SUKSD. EX SMALL =	1
SAHI	SAXIFRAGA	HIERACIFOLIA		WALDST. & KIT. =	
SAIN 2	SAXIFRAGA	INCOMPTA		PECK =	1
SAIN	SAXIFRAGA	INTEGRIFOLIA		HOOK. =SWAMP SAXIFRAGE	
SAINC	SAXIFRAGA	INTEGRIFOLIA	COLUMBIANA	(PIPER) C. L. HOOK. =	
SAINI	SAXIFRAGA	INTERGRIFOLIA	INTEGRIFOLIA	HOOK. =SWAMP SAXIFRAGE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SAJA	SAXIFRAGA	JAMESII		TORR. =	2
SALY	SAXIFRAGA	LYALLII		ENGL. =LYALL SAXIFRAGE	
SAMA	SAXIFRAGA	MARSHALLII		GREENE =	
SAMAD	SAXIFRAGA	MARSHALLII	DENTATA	ENGL. & IRMSCH. =	1
SAME 3	SAXIFRAGA	MERTENSIANA		BONG. =MERTENS SAXIFRAGE	
SANU	SAXIFRAGA	NUTTALLII		SMALL =	
SAOC 3	SAXIFRAGA	OCCIDENTALIS		WATS. =	
SAOCA	SAXIFRAGA	OCCIDENTALIS	ALLENII	(SMALL) C. L. HITCHC. =	
SAOCD	SAXIFRAGA	OCCIDENTALIS	DENTATA	(ENGL. & IRMSCH.) C. L. HITCHC. =	
SAOCI	SAXIFRAGA	OCCIDENTALIS	IOAHCENSIS	(PIPER) C. L. HITCHC. =	
SAOCL	SAXIFRAGA	OCCIDENTALIS	LATIPETIOLATA	C. L. HITCHC. =	
SAOCR	SAXIFRAGA	OCCIDENTALIS	RUFIDULA	(SMALL) C. L. HITCHC. =	
SAOP	SAXIFRAGA	OPPOSITIFOLIA		L. =TWINLEAF SAXIFRAGE	
SAOR	SAXIFRAGA	OREGANA		HOWELL =	
SAORM	SAXIFRAGA	OREGANA	MONTANENSIS	(SMALL) C. L. HITCHC. =	
SAORO	SAXIFRAGA	OREGANA	OREGANA	HOWELL =	
SAPA	SAXIFRAGA	PARVIFOLIA		GREENE =	
SAPE	SAXIFRAGA	PELTATA		TORR. EX BENTH. =UMBRELLA SAXIFRAGE	2
SAPU	SAXIFRAGA	PUNCTATA		L. =DOTTED SAXIFRAGE	
SAPUC	SAXIFRAGA	PUNCTATA	CASCADENSIS	(CALDER & SAVILE) C. L. HITCHC. =	
SAPUC2	SAXIFRAGA	PUNCTATA	CASCADENSIS	CALDER & SAVILE =	1
SARA 2	SAXIFRAGA	RANUNCULIFOLIA		HOOK. =	2
SARE	SAXIFRAGA	REFLEXA		HOOK. =	
SARH	SAXIFRAGA	RHOMBOIDEA		GREENE =DIAMONDLEAF SAXIFRAGE	
SARU	SAXIFRAGA	RUFIDULA		SMALL =REDWOOD SAXIFRAGE	1
SATO	SAXIFRAGA	TOLMIEI		T. & G. =TOLMIE SAXIFRAGE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C̄
SCAND	SCANDIX			(TOURN.) L.	=SHEPHERDS-NEEDLE; SCANDIX	
SCPE	SCANDIX	PECTEN-VENERIS		L.	=	
SCHEU	SCHEUCHZERIA			L.	=SCHEUCHZERIA	
SCPA 2	SCHEUCHZERIA	PALUSTRIS		L.	=	
SCPAA	SCHEUCHZERIA	PALUSTRIS	AMERICANA	FERN.	=	
SCHOE	SCHOENOCRAMBE			GREENE	=PLAINSMUSTARD	
SCLI	SCHOENOCRAMBE	LINIFOLIA		(NUTT.) GREENE	=FLAXLEAF PLAINSMUSTARD	
SCHOE2	SCHOENOLIRION			DURAND	=RUSHLILY	
SCAL	SCHOENOLIRION	ALBUM		DURAND	=	
SCSE	SCIRPUS	SETACEUS		L.	=BRISTLE LEAVED SEDGE	
SCOLI	SCOLIOPUS			TORR.	=FETID ADDERSTONGUE	
SCHA	SCOLIOPUS	HALLII		WATS.	=	
SCROP	SCROPHULARIA			L.	=FIGWORT	
SCCA	SCROPHULARIA	CALIFORNICA		CHAM. & SCHLECHT.	=CALIFORNIA FIGWORT	
SCLA	SCROPHULARIA	LANCEOLATA		PURSH	=LANCELEAF FIGWORT	
SCUTE	SCUTELLARIA			L.	=SKULLCAP	
SCAN	SCUTELLARIA	ANGUSTIFOLIA		PURSH	=NARROWLEAF SKULLCAP	
SCAN 2	SCUTELLARIA	ANTIRRHINOIDES		BENTH.	=	
SCEP	SCUTELLARIA	EPILOBIIFOLIA		HAMILT.	=	1
SCGA	SCUTELLARIA	GALERICULATA		L.	=WILLOWWEED SKULLCAP	
SCLA 2	SCUTELLARIA	LATERIFLORA		L.	=	
SCNA	SCUTELLARIA	NANA		GRAY	=DWARF SKULLCAP	
SCTU	SCUTELLARIA	TUBEROSA		BENTH.	=TUBEROUS SKULLCAP	
SEDUM	SEDUM			L.	=STONECROP	
SEDE	SEDUM	DEBILE		WATS.	=	
SEDI	SEDUM	DIVERGENS		WATS.	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
SEDO	SEDUM	DOUGLASII		HOOK. =DOUGLAS STONECROP	
SELA 2	SEDUM	LANCEOLATUM		TORR. =	
SELE	SEDUM	LEIBERGII		BRITT. =	
SEOR 2	SEDUM	OREGANUM		NUTT. =	
SEOR 3	SEDUM	OREGONENSE		(WATS.) PECK =	
SERO	SEDUM	ROSEUM		(L.) SCOP. =	
SESP	SEDUM	SPATHULIFOLIUM		HOOK. =SPATULA-LEAF STONECROP	
SEST	SEDUM	STENOPETALUM		PURSH =WORMLEAF STONECROP	
SEWA	SEDUM	WATSONI		TIDESTR. =WATSON STONECROP	1
SELAG	SELAGINELLA			BEAUV. =SELAGINELLA; LESSER CLUB-MOSS	
SEDE 3	SELAGENELLA	DENSA		R. & CB. =	
SEDED	SELAGINELLA	DENSA	DENSA	RYDB. =	
SEDES2	SELAGINELLA	DENSA	SCOPULORUM	(MAXON) TRYON =	
SEDES	SELAGINELLA	DENSA	STANDLEYI	(MAXON) TRYON =	
SEDO 2	SELAGINELLA	DOUGLASII		(HOOK. & GREV.) SPRING =DOUGLAS SELAGINELLA	
SEOR	SELAGINELLA	OREGANA		D. C. EAT. =	
SEWA 2	SELAGINELLA	WALLACEI		HIERON. =WALLACE SELAGINELLA	
SEWA 3	SELAGINELLA	WATSONII		UNDERW. =WATSON SELAGINELLA	
SENEC	SENECIO			L. =GROUNDSEL; RAGWORT	
SEAU	SENECIO	AUREUS		L. =GOLDEN GROUNDSEL	
SEBO	SENECIO	BOLANDERI		GRAY =	
SECA	SENECIO	CANUS		HOOK. =WOOLLY GROUNDSEL	
SECO	SENECIO	COLUMBIANUS		GREENE =COLUMBIA GROUNDSEL	1
SECO 2	SENECIO	CONDENSATUS		GREENE =	1
SECR	SENECIO	CRASSULUS		GRAY =THICKLEAF GROUNDSEL	
SECY	SENECIO	CYMBALARIOIDES		NUTT. =CLEFTLEAF GROUNDSEL	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
SECY 2	SENECIO	CYMBALARIOIDES		BUEK	
SEDE 2	SENECIO	DEBILIS		NUTT.	
SEEL	SENECIO	ELMERI		PIPER	
SEFL	SENECIO	FLAVULUS		GREENE	1
SEFL 2	SENECIO	FLETTII		WIEGAND	
SEFO	SENECIO	FOETIDUS		HOWELL	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
SEFOF	SENECIO	FOETIDUS	FOETIDUS	HOWELL	
SEFOH	SENECIO	FOETIDUS	HYDROPHYLLOIDES	(RYDB.) BARKL.	
SEFR	SENECIO	FREMONTII		T. & G.	
SEHA	SENECIO	HARFORDII		GREENM.	
SEHO	SENECIO	HOWELLII		GREENE	1
SEHY 2	SENECIO	HYDROPHILOIDES		RYDB.	1
SEHY	SENECIO	HYDROPHILUS		NUTT. =WATER GROUNDSEL	
SEIN 3	SENECIO	INDECORUS		GREENE	
SEIN	SENECIO	INTEGERRIMUS		NUTT. =LAMBSTONGUE GROUNDSEL	
SEINE	SENECIO	INTEGERRIMUS	EXALTATUS	(NUTT.) CRONQ.	
SEINI	SENECIO	INTEGERRIMUS	INTEGERRIMUS	NUTT. =LAMBSTONGUE GROUNDSEL	
SEINM	SENECIO	INTEGERRIMUS	MAJOR	(GRAY) CRONQ.	
SEINO	SENECIO	INTEGERRIMUS	OCHROLEUCUS	(GRAY) CRONQ.	
SEINV	SENECIO	INTEGERRIMUS	VASEYI	(GREENM.) CRONQ.	
SEIN 2	SENECIO	INTEGRIFOLIUS		HOOK.	1
SEJA	SENECIO	JACOBAEA		L. =TANSY RAGWORT; RAGWORT GROUNDSEL	
SELA	SENECIO	LAETIFLORUS		GREENE	1
SELU 2	SENECIO	LUGENS		RICH.	
SEMA	SENECIO	MACOUNII		GREENE	
SEME	SENECIO	MEGACEPHALUS		NUTT.	
SEMU 2	SENECIO	MULTILOBATUS		T. & G.	
SENE	SENECIO	NEOWEBSTERI		BLAKE	
SEPA 2	SENECIO	PAUCIFLORUS		PURSH	
SEPA	SENECIO	PAUPERCULUS		MICHX. =BALSAM GROUNDSEL	
SEPO	SENECIO	PORTERI		GREENE	
SEPS	SENECIO	PSEUDAUREUS		RYDB.	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
SEPU	SENECIO	PURSHIANUS		NUTT.	=	1
SERE	SENECIO	RESEDIFOLIUS		LESS.	=	
SESE	SENECIO	SERRA		HOOK.	=BUTTERWEED GROUNDSEL	
SESO	SENECIO	SONNEI		GREENE	=	1
SESP 2	SENECIO	SPHAEROCEPHALUS		GREENE	=	
SEST 2	SENECIO	STREPTANTHIFOLIUS		GREENE	=	
SESU	SENECIO	SUBNUDUS		DC.	=	1
SESY	SENECIO	SYLVATICUS		L.	=WOODLAND GROUNDSEL	
SETR	SENECIO	TRIANGULARIS		HOOK.	=ARROWLEAF GROUNDSEL	
SETW	SENECIO	TWEEDYI		RYDB.	=	1
SEUI	SENECIO	UINTAHENSIS		GREENM.	=	1
SEVU	SENECIO	VULGARIS		L.	=COMMON GROUNDSEL	
SEWE	SENECIO	WEBSTERI		GREENM.	=	1
SEWE 2	SENECIO	WERNERIAEFOLIUS		GRAY	=	
SERAP	SERAPIAS			L.	=	2
SEAU 2	SERAPIAS	AUSTINAE		EAT.	=	2
SHERA	SHERARDIA			L.	=BLUE FIELD-MADDER; HERB SHERARD	
SHAR	SHERARDIA	ARVENSIS		L.	=	
SIBBA	SIBBALDIA			L.	=SIBBALDIA	
SIPR	SIBBALDIA	PROCUMBENS		L.	=CREEPING SIBBALDIA	
SIDA	SIDA			L.	=ALKALI MALLOW; SIDA	
SIHE	SIDA	HEDERACEA		(DOUGL.) TORR. EX GRAY	=	
SIDAL	SIDALCEA			GRAY	=CHECKERMALLOW	
SICA	SIDALCEA	CAMPESTRIS		GREENE	=PLAINS CHECKERMALLOW	
SICR	SIDALCEA	CRENULATA		A. NELS.	=	1
SICU	SIDALCEA	CUSICKII		PIPER	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SIEX	SIDALCEA	EXIMIA		GREENE =	1
SIGL	SIDALCEA	GLAUCESCENS		GREENE =BIRD CHECKERMALLOW	
SIHE 2	SIDALCEA	HENDERSONII		WATS. =	
SIHI	SIDALCEA	HIRTIPES		C. L. HITCHC. =	
SINE	SIDALCEA	NELSONIANA		PIPER =	
SINEC	SIDALCEA	NEOMEXICANA	CRENULATA	(A. NELS.) C. L. HITCHC. =	
SIOR	SIDALCEA	OREGANA		(NUTT.) GRAY =OREGON CHECKERMALLOW	
SIORE	SIDALCEA	OREGANA	EXIMIA	(GREENE) HITCHC. =	
SIORO	SIDALCEA	OREGANA	OREGANA	(NUTT.) GRAY =OREGON CHECKERMALLOW	
SIORP	SIDALCEA	OREGANA	PROCERA	C. L. HITCHC. =	
SISP	SIDALCEA	SPICATA		GREENE =SPIKE CHECKERMALLOW	1
SIVI	SIDALCEA	VIRGATA		HOWELL =	
SIEVE	SIEVERSIA			WILLD. =	2
SILEN	SILENE			L. =SILENE; CAMPION; WILD PINK	
SIAC	SILENE	ACAULIS		L. =MOSS SILENE	
SIAN 2	SILENE	ANTIRRHINA		L. =	
SICA 2	SILENE	CAMPANULATA		WATS. =	
SICO	SILENE	COLUMBIANA		HOWELL =	1
SIDO 2	SILENE	DOUGLASII		HOOK. =DOUGLAS SILENE	
SIGA	SILENE	GALLICA		L. =FRENCH SILENE	
SIHO	SILENE	HOOKERI		NUTT. =HOOKER SILENE	
SIIN	SILENE	INGRAMI		TIDESTR. & DAYT. =INGRAM SILENE	1
SILY	SILENE	LYALLII		WATS. =LYALL SILENE	1
SIMA	SILENE	MACOUNII		WATS. =MACOUN SILENE	1
SIME	SILENE	MENZIESII		HOOK. =MENZIES SILENE	
SIMO	SILENE	MONTANA		WATS. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME
SIMU	SILENE	MULTICAULIS		NUTT.	=BUSHY SILENE
SINO	SILENE	NOCTIFLORA		L.	=NIGHTFLOWERING SILENE
SIOR 2	SILENE	OREGANA		WATS.	=OREGON SILENE
SIPA	SILENE	PARRYII		(WATS.) HITCHC. & MAG.	=
SIRE	SILENE	REPENS		PERS.	=
SIREA	SILENE	REPENS	AUSTRALE	(HITCHC. & MAGUIRE) HITCHC.	=
SISC 2	SILENE	SCAPOSA		ROBINS.	=
SISC	SILENE	SCOULERI		HOOK.	=SCOULER SILENE
SISE	SILENE	SEELYI		MORT. & THOMPS.	=
SISP 2	SILENE	SPALDINGII		WATS.	=
SISU 2	SILENE	SUKSDORFII		ROBINS.	=
SILYB	SILYBUM			ADANS.	=MILK THISTLE
SIMA 2	SILYBUM	MARIANA		(L.) GAERTN.	=
SIMA 3	SILYBUM	MARIANUM		(L.) GAERTN.	=
SISYM	SISYMBRIUM			L.	=TUMBLEMUSTARD
SIAL	SISYMBRIUM	ALTISSIMUM		L.	=TUMBLEMUSTARD
SILO	SISYMBRIUM	LOESELII		L.	=
SIOF	SISYMBRIUM	OFFICINALE		(L.) SCOP.	=
SISYR	SISYRINCHIUM			L.	=BLUE-EYEDGRASS
SIAN	SISYRINCHIUM	ANGUSTIFOLIUM		MILL.	=COMMON BLUE-EYEDGRASS
SIBE	SISYRINCHIUM	BELLUM		WATS.	=WESTERN BLUE-EYEDGRASS
SICA 3	SISYRINCHIUM	CALIFORNICUM		(KER.-GAWL) DRYAND.	=GOLDEN BLUE-EYEDGRASS
SIDO	SISYRINCHIUM	DOUGLASII		A. DIETR.	=DOUGLAS BLUE-EYEDGR
SIID	SISYRINCHIUM	IDAHOENSE		BICKN.	=IDAHO BLUE-EYEDGR
SIIN 2	SISYRINCHIUM	INFLATUM		(SUKSD.) ST.JOHN.	=
SISA	SISYRINCHIUM	SARMENTOSUM		SUKSD.	=

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SIUM	SIUM			L. =WATERPARSNIP	
SISU	SIUM	SUAVE		WALT. =HEMLOCK WATERPARSNIP	
SMELO	SMELOWSKIA			C. A. MEY. =SMELOWSKIA	
SMCA	SMELOWSKIA	CALYCINA		(STEPH.) C. A. MEY. =ALPINE SMELOWSKIA	
SMFR	SMELOWSKIA	FREMONTII		WATS. =	1
SMOV	SMELOWSKIA	OVALIS		M. E. JONES =	
SMILA	SMILACINA			DESF. =SOLOMONPLUME	
SMRA	SMILACINA	RACEMOSA		(L.) DESF. =FEATHER SOLOMONPLUME	
SMSE	SMILACINA	SESSILIFOLIA		NUTT. =SLIM SOLOMONPLUME	1
SMST	SMILACINA	STELLATA		(L.) DESF. =STARRY SOLOMONPLUME	
SMSTS	SMILACINA	STELLATA	SESSILIFOLIA	HENDERS. =	1
SMRAA	SMILICINA	RACEMOSA	AMPLEXICAULIS	WATS. =	1
SOLAN	SOLANUM			L. =NIGHTSHADE	
SOCA 3	SOLANUM	CAROLINENSE		L. =	
SODO	SOLANUM	DOUGLASII		DUNAL =DOUGLAS NIGHTSHADE	
SODU 2	SOLANUM	DULCAMARA		L. =BITTER NIGHTSHADE	
SONI	SOLANUM	NIGRUM		L. =BLACK NIGHTSHADE	
SORO	SOLANUM	ROSTRATUM		DUNAL =	
SOSA 2	SOLANUM	SARRACHOIDES		SENDT. =	
SOTR	SOLANUM	TRIFLORUM		NUTT. =CUTLEAF NIGHTSHADE	
SOUM	SOLANUM	UMBELLIFERUM		ESCHS. =UMBELLED NIGHTSHADE	1
SOVI	SOLANUM	VILLOSUM		AUTHORS NOT L. =	1
SOXA	SOLANUM	XANTII		GRAY =PURPLE NIGHTSHADE	
SOLID	SOLIDAGO			L. =GOLDENROD	
SOCA	SOLIDAGO	CANADENSIS		L. =CANADA GOLDENROD	
SOCAC	SOLIDAGO	CANADENSIS	CANADENSIS	L. =CANADA GOLDENROD	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
SOCAS	SOLIDAGO	CANADENSIS	SALEBROSA	(PIPER) JONES	=	
SOCI	SOLIDAGO	CILIOSA		GREENE	=	1
SOGL	SOLIDAGO	GLUTINOSA		NUTT.	=	1
SOMI	SOLIDAGO	MISSOURIENSIS		NUTT.	=MISSOURI GOLDENROD	
SOMU	SOLIDAGO	MULTIRADIATA		AIT.	=LCW GCLDENROD	
SOMUM	SOLIDAGO	MULTIRADIATA	MULTIRACIATA	AIT.	=LCW GCLDENROD	
SOMUS	SOLIDAGO	MLLTIRADIATA	SCOPULORUM	GRAY	=	
SONA	SOLIDAGO	NANA		NUTT.	=	
SOOC 2	SOLIDAGO	OCCIDENTALIS		(NUTT.) T. & G.	=	
SOSC	SOLIDAGO	SCOPULORUM		NELS.	=	1
SOSP 2	SOLIDAGO	SPATHULATA		DC.	=CCAST GOLDENROD	
SOSPN	SOLIDAGO	SPATHULATA	NANA	(GRAY) CRONQ.	=	
SOSPN2	SOLIDAGO	SPATHULATA	NEOMEXICANA	(GRAY) CRONQ.	=	
SOSPS	SOLIDAGO	SPATHULATA	SPATHULATA	DC.	=	
SOSP	SOLIDAGO	SPECTABILIS		(D. C. EAT.) GRAY	=NEVADA GOLDENRCD	
SONCH	SONCHUS			L.	=SOWTHISTLE	
SOAR	SONCHUS	ARVENSIS		L.	=	
SOAS	SONCHUS	ASPER		(L.) HILL	=PRICKLY SOWTHISTLE	
SOOL	SONCHUS	OLERACEUS		L.	=	
SOUL	SONCHUS	ULIGINOSUS		BIEB.	=	
SOPHI	SOPHIA			L.	=	2
SOPA	SOPHIA	PARVIFLORA		STANDL.	=	2
SOPHO	SOPHORA			L.	=SOPHORA	
SOLE	SOPHORA	LEACHIANA		PECK	=	
SPARG	SPARGANIUM			L.	=BURREED	
SPAN	SPARGANIUM	ANGUSTIFOLIUM		MICHX.	=NARROWLEAF BURREED	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
SPEU	SPARGANIUM	EURYCARPUM		ENGELM.	=	
SPMI 2	SPARGANIUM	MINIMUM		FRIES	=	
SPSI	SPARGANIUM	SIMPLEX		HUDS.	=SIMPLESTEM BURREED	
SPERG2	SPERGULA			L.	=SPURRY	
SPAR 2	SPERGULA	ARVENSIS		L.	=	
SPERG	SPERGULARIA			J. & PRESL.	=SANDSPURRY	
SPCA 2	SPERGULARIA	CANADENSIS		(PERS.) G. DON	=	
SPDI	SPERGULARIA	DIANDRA		(GUSS.) BOISS.	=	
SPMA 2	SPERGULARIA	MACROTHECA		(HORNEM.) HEYNH.	=	
SPMA	SPERGULARIA	MARINA		(L.) GRISEB.	=	
SPME 2	SPERGULARIA	MEDIA		(L.) PRESL.	=	
SPRU	SPERGULARIA	RUBRA		(L.) J. & C. PRESL.	=RED SANDSPURRY	
SPHAE	SPHAERALCEA			A. ST. - HIL.	=GLOBEMALLOW	
SPCO	SPHAERALCEA	COCCINEA		(PURSH) RYDB.	=RED GLOBEMALLOW	
SPGR 2	SPHAERALCEA	GROSSULARIAEFOLIA		(H. & A.) RYDB.	=GOOSEBERRYLEAF GLOBEMALLOW	
SPLO	SPHAERALCEA	LONGISEPALA		TORR.	=	1
SPMU	SPHAERALCEA	MUNROANA		(DOUGL.) SPACH EX GRAY	=MUNRO GLOBEMALLOW	
SPRI	SPHAERALCEA	RIVULARIS		TORR. EX GRAY	=STREAM GLOBEMALLOW	2
SPHEN	SPHENOSCIADIUM			GRAY	=WOOLLYHEADPARSNIP	
SPCA	SPHENOSCIADIUM	CAPITELLATUM		GRAY	=RANGE WOOLLYHEADPARSNIP	
SPIRA2	SPIRANTHES			L. C. RICH.	=LADIESTRESSES	
SPRO	SPIRANTHES	ROMANZOFFIANA		CHAM.	=CONTINENTAL LADIESTRESSES	
SPIRO	SPIRODELA			SCHLEID.	=GREATER DUCKWEED	
SPPO	SPIRODELA	POLYRHIZA		(L.) SCHLEID.	=	
SPRAG	SPRAGUEA			TORR.	=PUSSYPAWS	
SPNU	SPRAGUEA	NUDA		(GREENE) HOWELL	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
SPUM	SPRAGUEA	UMBELLATA		TORR. =UMBELLATE PUSSYPAWS	
SPUMC	SPRAGUEA	UMBELLATA	CAUDICIFERA	GRAY =MT. HOOD PUSSYPAWS	
SPUMU	SPRAGUEA	UMBELLATA	UMBELLATA	TORR. =UMBELLATE PUSSYPAWS	
STACH	STACHYS			L. =BETONY; HEDGE-NETTLE	
STBU	STACHYS	BULLATA		BENTH. =PUFFNETTLE BETONY	1
STCI	STACHYS	CILIATA		DOUGL. EX BENTH. =	1
STCO 4	STACHYS	COOLEYAE		HELLER =	
STME 2	STACHYS	MEXICANA		BENTH. =	
STPA 2	STACHYS	PALUSTRIS		L. =MARSH BETONY	
STRI	STACHYS	RIGIDA		NUTT. EX BENTH. =	
STSC	STACHYS	SCOPULORUM		GREENE =	1
STANL	STANLEYA			NUTT. =PRINCES PLUME; STANLEYA	
STCO 3	STANLEYA	CONFERTIFLORA		(ROBINS) HOW. =	
STPI	STANLEYA	PINNATA		(PURSH) BRITT. =	
STTO	STANLEYA	TOMENTOSA		PARRY =	
STTOR	STANLEYA	TOMENTOSA	RUNCINATA	(RYDB.) ROLLINS =	
STVI 2	STANLEYA	VIRIDIFLORA		NUTT. =	
STARC	STATICE	ARCTICA	CALIFORNICA	BLAKE =	2
STEIR	STEIRONEMA			RAF. =	2
STCI 2	STEIRONEMA	CILIATUM		(L.) RAF. =	
STLA 3	STEIRONEMA	LANCEOLATUM		(WALT.) GRAY =	
STELL	STELLARIA			L. =STARWORT	
STAL	STELLARIA	ALPESTRIS		FRIES. =	1
STBO	STELLARIA	BOREALIS		BIGEL. =NORTHERN STARWORT	1
STCA 2	STELLARIA	CALYCANTHA		(LEDEB.) BONG. =	
STCAC	STELLARIA	CALYCANTHA	CALYCANTHA	(LEDEB.) BONG. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
STCAS	STELLARIA	CALYCANTHA	SITCHANA	(STEUD.) FERN. =	
STCR 2	STELLARIA	CRASSIFOLIA		EHRH. =	
STCR	STELLARIA	CRISPA		CHAM. & SCHLECHT. =	
STHU	STELLARIA	HUMIFUSA		ROTTB. =LOW STARWORT	
STJA	STELLARIA	JAMESIANA		TORR. =TUBER STARWORT	
STLA	STELLARIA	LAETA		RICHARDS. =	1
STLO 2	STELLARIA	LONGIFOLIA		MUHL. EX WILLD. =	
STLO	STELLARIA	LONGIPES		GOLDIE =LONGSTALK STARWORT	
STME	STELLARIA	MEDIA		(L.) CYRILL. =CHICKWEED	
STNI	STELLARIA	NITENS		NUTT. =	
STOB	STELLARIA	OBTUSA		ENGELM. =	
STSI	STELLARIA	SIMCOEI		(HOWELL) C. L. HITCHC. =	
STUM	STELLARIA	UMBELLATA		TURCZ. EX KAR. & KIR. =	
STENA	STENANTHIUM			KUNTH =STENANTHIUM	
STOC 2	STENANTHIUM	OCCIDENTALE		GRAY =WESTERN STENANTHIUM	
STEPH	STEPHANOMERIA			NUTT. =WIRELETTUCE	
STEX	STEPHANOMERIA	EXIGUA		NUTT. =	
STLA 2	STEPHANOMERIA	LACTUCINA		GRAY =	
STPA	STEPHANOMERIA	PANICULATA		NUTT. =	
STTE	STEPHANOMERIA	TENUIFOLIA		(TORR.) HALL =	
STREP2	STREPTANTHELLA			RYDB. =STREPTANTHELLA	
STLO 3	STREPTANTHELLA	LONGIROSTRIS		(WATS.) RYDB. =	
STREP	STREPTOPUS			L. C. RICH. =TWISTEDSTALK	
STAM	STREPTOPUS	AMPLEXIFOLIUS		(L.) DC. =CLASPLEAF TWISTEDSTALK	
STCU	STREPTOPUS	CURVIPES		VAIL =	1
STRO	STREPTOPUS	ROSEUS		MICHX. =ROSY TWISTEDSTALK	

SPP. CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
STROC	STREPTOPUS	ROSEUS	CURVIPES	HULTEN =	
STST	STREPTOPUS	STREPTOPOIDES		(LEDEB.) FRYC & RIGG. =	
STSTB	STREPTOPUS	STREPTOPOIDES	BREVIPES	CALDER & TAYLOR =	
STYLO	STYLOCLINE			NUTT. =STYLOCLINE	
STFI	STYLOCLINE	FILAGINEA		GRAY =	
STPS	STYLOCLINE	PSILOCARPHOIDES		PECK =	
SUAED	SUAEDA			FORSK. =SEABLITE	
SUDE	SUAEDA	DEPRESSA		(PURSH) WATS. =	
SUIN	SUAEDA	INTERMEDIA		WATS. =	
SUMA	SUAEDA	MARITIMA		(L.) DUMCRT. =	
SUNI	SUAEDA	NIGRA		(RAF.) MACBR. =	
SUOC	SUAEDA	OCCIDENTALIS		WATS. =	
SUKSD	SUKSDORFIA			GRAY =SUKSDORFIA	
SURA	SUKSDORFIA	RANUNCULIFOLIA		(HOOK.) ENGL. =	
SUVI	SUKSDORFIA	VIOLACEA		GRAY =VIOLET SUKSDORFIA	
SWAIN	SWAINSONA			SALISB. =SWAINSONA	
SWSA	SWAINSONA	SALSULA		(PALL.) TAUB. =	
SWERT	SWERTIA			ALL. =SWERTIA	
SWAL	SWERTIA	ALBICAULIS		(GRISEB.) KTZE. =	
SWMO	SWERTIA	MODOCENSIS		ST.JOHN =	1
SWPE	SWERTIA	PERENNIS		L. =ALPINEBOG SWERTIA	
SYMPH2	SYMPHYTUM			L. =COMFREY	
SYAS	SYMPHYTUM	ASPERUM		LEPECH. =	
SYOF	SYMPHYTUM	OFFICINALE		L. =	
SYNTH	SYNTHYRIS			BENTH. =KITTENTAILS	
SYMI	SYNTHYRIS	MISSURICA		(RAF.) PENNELL =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SYPI	SYNTHYRIS	PINNATIFIDA		WATS. =	
SYPIC	SYNTHYRIS	PINNATIFIDA	CANESCENS	(PENNELL) CRONQ. =	
SYPIL	SYNTHYRIS	PINNATIFIDA	LANUGINOSA	(PIPER) CRONQ. =	
SYRE	SYNTHYRIS	RENIFORMIS		(DOUGL.) BENTH. =	
SYRU	SYNTHYRIS	RUBRA		BENTH. =	2
SYSC	SYNTHYRIS	SCHIZANTHA		PIPER =	
TALIN	TALINUM			ADANS. =FLAMEFLOWER; TALINUM	
TAOK	TALINUM	CKANOGANENSE		ENGLISH =	
TASP	TALINUM	SPINESCENS		TORR. =	
TANAC	TANACETUM			L. =TANSY	
TACA	TANACETUM	CAMPHORATUM		LESS. =DUNE TANSY	
TADO	TANACETUM	DOUGLASII		DC. =	
TANU	TANACETUM	NUTTALLII		T. & G. =	
TAPO	TANACETUM	POTENTILLOIDES		GRAY =	
TAVU	TANACETUM	VULGARE		L. =COMMON TANSY	
TARAX	TARAXACUM			L. =DANDELION	
TACE	TARAXACUM	CERATOPHORUM		(LEDEB.) =	
TAER	TARAXACUM	ERIOPHORUM		RYDB. =	
TALA	TARAXACUM	LAEVIGATUM		(WILLD.) DC. =SMOOTH DANDELION	
TAOF	TARAXACUM	OFFICINALE		WEBER =COMMON DANDELION	
TAUSC	TAUSCHIA			SCHLECT. =TAUSCHIA	
TAHO	TAUSCHIA	HOOVERI		MATH. & CONST. =	
TAST	TAUSCHIA	STRICKLANDII		(COULT. & ROSE) MATH. & CONST. =	
TEESD	TEESDALIA			R. BR. =SHEPHERDS CRESS	
TENU	TEESDALIA	NUDICAULIS		(L.) R. BR. =	
TELES	TELESONIX			RAF. =TELESONIX	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
TEJA	TELESONIX	JAMESII		(TORR.) RAF. =	
TELLI	TELLIMA			R. BR. =FRINGECUP	
TEGR	TELLIMA	GRANDIFLORA		(PURSH) DOUGL. =ALASKA FRINGECUP	
TEUCR	TEUCRIUM			L. =GERMANDER; WOOD SAGE	
TECA 2	TEUCRIUM	CANADENSE		L. =	
THALE	THALESIA			RAF. =	2
THFA	THALESIA	FASCICULATA		BRITT. =	2
THUN	THALESIA	UNIFLORA		BRITT. =	2
THALI	THALICTRUM			L. =MEADOWRUE	
THAL 2	THALICTRUM	ALPINUM		L. =	
THDA	THALICTRUM	DASYCARPUM		FISCH. =	
THFE 2	THALICTRUM	FENDLERI		ENGELM. =FENDLER MEADOWRUE	
THOC	THALICTRUM	OCCIDENTALE		GRAY =WESTERN MEADOWRUE	
THPO	THALICTRUM	POLYCARPUM		(TORR.) WATS. =	
THSP	THALICTRUM	SPARSIFLORUM		TURCZ. EX FISCH. & MEY. =	
THVE	THALICTRUM	VENULOSUM		TREL. =VEINY MEADOWRUE	
THELY	THELYPODIUM			ENDL. =THELYPODY	
THBR	THELYPODIUM	BRACHYCARPUM		TORR. =	
THEU	THELYPODIUM	EUCOSMUM		ROBINS. =	
THHO	THELYPODIUM	HOWELLII		WATS. =	
THIN	THELYPODIUM	INTEGRIFOLIUM		(NUTT.) ENDL. =	
THLA	THELYPODIUM	LACINIATUM		(HOOK.) ENDL. =	
THLA 2	THELYPODIUM	LASIOPHYLLUM		(HOOK. & ARN.) GREENE =	
THRE	THELYPODIUM	REPANDUM		ROLLINS =	
THSA	THELYPODIUM	SAGITTATUM		(NUTT.) ENDL. =	
THELY2	THELYPTERIS			SCHMIDEL =WOODFERN	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
THLI	THELYPTERIS	LIMBOSPERMA		(ALLIONI) H. P. FUCHS =	
THNE	THELYPTERIS	NEVADENSIS		(BAKER) CLUTE EX MORTON =	
THPH	THELYPTERIS	PHEGOPTERIS		(L.) SLOSSON =	
THERM	THERMOPSIS			R. BR. =THERMOPSIS; BUCKBEAN; GOLDEN PEA	
THGR	THERMOPSIS	GRACILIS		HOWELL =	1
THMO	THERMOPSIS	MONTANA		NUTT. =MOUNTAIN THERMOPSIS	
THMOM	THERMOPSIS	MONTANA	MONTANA	NUTT. =MOUNTAIN THERMOPSIS	
THMOO	THERMOPSIS	MONTANA	OVATA	(ROBINS.) ST.JOHN. =	
THMOV	THERMOPSIS	MONTANA	VENOSA	(EASTW.) JEPS. =SHASTA THERMOPIS	
THOV	THERMOPSIS	OVATA		RYDB. =	1
THLAS	THLASPI			L. =PENNYCRESS	
THAL	THLASPI	ALPESTRE		L. =	1
THAR	THLASPI	ARVENSE		L. =FIELD PENNYCRESS	
THFE	THLASPI	FENDLERI		GRAY =BLUE PENNYCRESS	
THFEF	THLASPI	FENDLERI	FENDLERI	GRAY =BLUE PENNYCRESS	
THFEG	THLASPI	FENDLERI	GLAUCUM	(A. NELS.) C. HITCHC. =	
THGL	THLASPI	GLAUCUM		A. NELS. =BLUE PENNYCRESS	1
THPA	THLASPI	PARVIFLORUM		A. NELS. =	
THPE	THLASPI	PERFOLIATUM		L. =	
THYMU	THYMUS			L. =THYME	
THSE	THYMUS	SERPYLLUM		L. =	
THYSA	THYSANOCARPUS			HOOK. =LACEPOD; FRINGED-POD	
THCU	THYSANOCARPUS	CURVIPES		HOOK. =FRINGED-POD	
THEL	THYSANOCARPUS	ELEGANS		F. & M. =	1
TIARE	TIARELLA			L. =FOAMFLOWER; COOLWART	
TILA	TIARELLA	LACINIATA		HOOK. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
TITR	TIARELLA	TRIFOLIATA		L.	=	
TIUN	TIARELLA	UNIFOLIATA		HOOK.	=COOLWART FOAMFLOWER	
TITHY	TITHYMALUS			HALLER	=	2
TICR	TITHYMALUS	CRENULATUS		HELLER	=	2
TISH	TIUM	SHELDONI		RYDB.	=	2
TOFIE	TOFIELDIA			HUDS.	=TOFIELDIA	
TOGL	TOFIELDIA	GLUTINOSA		(MICHX.) PERS.	=	
TOGLA	TOFIELDIA	GLUTINOSA	ABSONA	DAVIS	=	
TOGLB	TOFIELDIA	GLUTINOSA	BREVISTYLA	(HITCHC.) C. L. HITCHC. HOC LOC.	=	
TOGLG	TOFIELDIA	GLUTINOSA	GLUTINOSA	(MICHX.) PERS.	=	
TOGLM	TOFIELDIA	GLUTINOSA	MONTANA	DAVIS	=	
TOGLO	TOFIELDIA	GLUTINOSA	OCCIDENTALIS	(WATS.) C. L. HITCHC.		
TOOC	TOFIELDIA	OCCIDENTALIS		WATS.	=TALL TOFIELDIA	
TOLMI	TOLMIEA			T. & G.	=TOLMIEA	
TOME	TOLMIEA	MENZIESII		(PURSH) T. & G.	=MENZIES TOLMIEA	
TONEL	TONELLA			NUTT.	=TONELLA	
TOFL 2	TONELLA	FLORIBUNDA		GRAY	=	
TOTE	TONELLA	TENELLA		(BENTH.) HELLER	=	
TOAR	TORILIS	ARVENSIS		(HUDS.) LINK.	=	
TONO	TORILIS	NODOSA		(L.) GAERTN.	=KNOTTED HEDGEPARSLEY	
TOWNS	TOWNSENDIA			HOOK.	=TOWNSENDIA	
TOFL	TOWNSENDIA	FLORIFER		(HOOK.) GRAY	=SHOWY TOWNSENDIA	
TOHO	TOWNSENDIA	HOOKERI		BEDMAN	=	
TOME 2	TOWNSENDIA	MENSANA		JONES	=	1
TOMO	TOWNSENDIA	MONTANA		JONES	=	
TOPA	TOWNSENDIA	PARRYI		EAT.	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
TOSP	TOWNSENDIA	SPATHULATA		NUTT.	=	
TRAGO	TRAGOPOGON			L.	=SALSIFY; GOATSBEARD	
TRDU	TRAGOPOGON	DUBIUS		SCOP.	=	
TRMI 3	TRAGOPOGON	MIRUS		OWNBEY	=	
TRMI 4	TRAGOPOGON	MISCELLUS		OWNBEY	=	
TRPO	TRAGOPOGON	PORRIFOLIUS		L.	=VEGETABLE-OYSTER; SALSIFY	
TRPR 4	TRAGOPOGON	PRATENSIS		L.	=	
TRAUT	TRAUTVETTERIA			FISCH. & MEY.	=FALSEBUGBANE	
TRCA 3	TRAUTVETTERIA	CAROLINIENSIS		(WALT.) VAIL	=	
TRCAO	TRAUTVETTERIA	CAROLINIENSIS	OCCIDENTALIS	(GRAY) C. L. HITCHC.	=	
TRGR	TRAUTVETTERIA	GRANDIS		NUTT. EX T. & G.	=OREGON FALSEBUGBANE	
TRIBU	TRIBULUS			L.	=PUNCTURE-VINE; LAND CALTROP; GROUND BUR-NUT	
TRTE	TRIBULUS	TERRESTRIS		L.	=	
TRICH	TRICHOSTEMA			L.	=BLUECURLS	
TRLA 3	TRICHOSTEMA	LANCEOLATUM		BENTH.	=VINEGAR BLUECURLS	
TROB	TRICHOSTEMA	OBLONGUM		BENTH.	=	
TRIEN	TRIENTALIS			L.	=STARFLOWER	
TRAR 2	TRIENTALIS	ARCTICA		FISCH. EX HOOK.	=	
TRLA 2	TRIENTALIS	LATIFOLIA		HOOK.	=WESTERN STARFLOWER	
TRIFO	TRIFOLIUM			L.	=CLOVER; TREFOIL	
TRAL	TRIFOLIUM	ALBOPURPUREUM		T. & G.	=RANCHERIA CLOVER	1
TRAM	TRIFOLIUM	AMPLECTENS		T. & G.	=BLADDER CLOVER	
TRAR	TRIFOLIUM	ARCUATUM		PIPER	=SPINDLEROOT CLOVER	1
TRBE	TRIFOLIUM	BECKWITHII		BREW. EX WATS.	=BECKWITH CLOVER	
TRBI	TRIFOLIUM	BIFIDUM		GRAY	=PINOLE CLOVER	
TRBR	TRIFOLIUM	BREWERI		WATS.	=BREWER CLOVER	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
TRCA 2	TRIFOLIUM	CAMPESTRE		SCHREB. =LOW HOP CLOVER	1
TRCI	TRIFOLIUM	CILIOLATUM		BENTH. =FOOTHILL CLOVER	
TRCY	TRIFOLIUM	CYATHIFERUM		LINDL. =CUP CLOVER	
TRDE	TRIFOLIUM	DEPAUPERATUM		DESV. =	
TRDO	TRIFOLIUM	DOUGLASII		HOUSE =DOUGLAS CLOVER	
TRDU 2	TRIFOLIUM	DUBIUM		SIBTH. =SUCKLING CLOVER	
TRER	TRIFOLIUM	ERIOCEPHALUM		NUTT. =WOOLLYHEAD CLOVER	
TRERC	TRIFOLIUM	ERIOCEPHALUM	CUSICKII	(PIPER) MARTIN =	
TRERE	TRIFOLIUM	ERIOCEPHALUM	ERIOCEPHALUM	NUTT. =	
TRERP	TRIFOLIUM	ERIOCEPHALUM	PIPERI	MARTIN =	
TRFI	TRIFOLIUM	FIMBRIATUM		LINDL. =COLUMBIA CLOVER	1
TRFR	TRIFOLIUM	FRAGIFERUM		L. =STRAWBERRY CLOVER	
TRFU	TRIFOLIUM	FUCATUM		LINDL. =PUFF CLOVER	
TRGR 2	TRIFOLIUM	GRACILENTUM		T. & G. =	
TRGY	TRIFOLIUM	GYMNOCARPON		NUTT. =HOLLYLEAF CLOVER	
TRHA	TRIFOLIUM	HALLII		HOW. =HALLS CLOVER	1
TRHA 2	TRIFOLIUM	HANSENI		GREENE =HANSEN CLOVER	1
TRHA 3	TRIFOLIUM	HARNEYENSE		HOW. =	1
TRHA 4	TRIFOLIUM	HAYDENI		PORTER =HAYDEN CLOVER	
TRHO	TRIFOLIUM	HOWELLII		WATS. =BIGLEAF CLOVER	
TRHY	TRIFOLIUM	HYBRIDUM		L. =ALSIKE CLOVER	
TRIN	TRIFOLIUM	INCARNATUM		L. =CRIMSON CLOVER	
TRKI	TRIFOLIUM	KINGII		WATS. =KINGS CLOVER	
TRLA	TRIFOLIUM	LATIFOLIUM		(HOOK.) GREENE =TWIN CLOVER	
TRLO	TRIFOLIUM	LONGIPES		NUTT. =LONGSTALK CLOVER	
TRLOE	TRIFOLIUM	LONGIPES	ELMERI	E. MCDER. =ELMERCREW CLOVER	1

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TRLOL	TRIFOLIUM	LONGIPES	LONGIPES	NUTT. =LONGSTALK CLOVER
TRMA 3	TRIFOLIUM	MACRAEI		H. & A. =
TRMAA	TRIFOLIUM	MACRAEI	ALBOPURPUREUM	(T. & G.) GREENE =
TRMA	TRIFOLIUM	MACROCEPHALUM		(PURSH) POIRET =BIGHEAD CLOVER
TRMI	TRIFOLIUM	MICROCEPHALUM		PURSH =LITTLEHEAD CLOVER
TRMI 2	TRIFOLIUM	MICRODON		H. & A. =
TRMU	TRIFOLIUM	MULTIPEDUNCULATUM		KENNEDY =
TROL	TRIFOLIUM	OLIGANTHUM		STEUD. =
TRPL	TRIFOLIUM	PLUMOSUM		DOUGL. EX HOOK. =PUSSY CLOVER
TRPLA	TRIFOLIUM	PLUMOSUM	AMPLIFOLIUM	MARTIN =
TRPR	TRIFOLIUM	PRATENSE		L. =RED CLOVER
TRPR 2	TRIFOLIUM	PROCUMBENS		L. =LOW HOP CLOVER
TRPR 3	TRIFOLIUM	PRODUCTUM		GREENE =
TRRE	TRIFOLIUM	REPENS		L. =WHITE CLOVER
TRSU	TRIFOLIUM	SUBTERRANEUM		L. =SUBTERRANEAN CLOVER
TRTH	TRIFOLIUM	THOMPSONII		MORTON =
TRTR	TRIFOLIUM	TRIDENTATUM		LINDL. =TOMCAT CLOVER
TRVA	TRIFOLIUM	VARIEGATUM		NUTT. =WHITETIP CLOVER
TRWO 2	TRIFOLIUM	WORMSKJOLDI		LEHM. =ARROW-GRASS; PCCGRASS
TRILL	TRILLIUM			L. =TRILLIUM
TRCH	TRILLIUM	CHLOROPETALUM		(TORR.) HOWELL =
TROV	TRILLIUM	OVATUM		PURSH =PACIFIC TRILLIUM
TRPE	TRILLIUM	PETIOLATUM		PURSH =IDAHO TRILLIUM
TRRI	TRILLIUM	RIVALE		WATS. =OREGON TRILLIUM
TRIOD	TRIODANIS			RAF. =TRIODANIS
TRPE 2	TRIODANIS	PERFOLIATA		(L.) NIEUWL. =

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
TROLL	TROLLIUS			L. =GLOBEFLOWER	
TRAL 2	TROLLIUS	ALBIFLORUS		RYDB. =WHITE GLOBEFLOWER	1
TRLA 4	TROLLIUS	LAXUS		SALISB. =	
TRLAA	TROLLIUS	LAXUS	ALBIFLORUS	(RYDB.) GRAY =	
TRLAL	TROLLIUS	LAXUS	LAXUS	SALISB. =	
TURRI	TURRITIS			L. =	1
TUGL	TURRITIS	GLABRA		L. =TOWER MUSTARD	2
TUSSI	TUSSILAGO			L. =COLTSFOOT	
TUFA	TUSSILAGO	FARFARA		L. =	
TYPHA	TYPHA			L. =CATTAIL	
TYLA	TYPHA	LATIFOLIA		L. =COMMON CATTAIL	
URTIC	URTICA			L. =NETTLE	
URBR	URTICA	BREWERI		WATS. =	1
URDI	URTICA	DIOICA		L. =	
URDID	URTICA	DIOICA	DIOICA	L. =	
URDIG	URTICA	DIOICA	GRACILIS	(AIT.) SELAND =	
URDIH	URTICA	DIOICA	HOLOSERICEA	(NUTT.) C. L. HITCHC. =	
URDIL	URTICA	DIOICA	LYALLII	(WATS.) C. L. HITCHC. =	
URGR	URTICA	GRACILIS		AIT. =SLIM NETTLE	1
URHO	URTICA	HOLOSERICEA		NUTT. =HOARY NETTLE	1
URLY	URTICA	LYALLII		WATS. =LYALL NETTLE	1
URUR	URTICA	URENS		L. =	
UTRIC	UTRICULARIA			L. =BLADDERWORT	
UTVU	UTRICULARIA	VULGARIS		L. =COMMON BLADDERWORT	
VACCA	VACCARIA			MEDIK. =COWHERB	
VASE	VACCARIA	SEGETALIS		(NECK.) GARCKE EX ASCH. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
VALER	VALERIANA			L. =VALERIAN	
VAAC	VALERIANA	ACUTILOBA		RYDB. =	
VAACA	VALERIANA	ACUTILOBA	ACUTILOBA	RYDB. =	
VACO	VALERIANA	COLUMBIANA		PIPER =COLUMBIA VALERIAN	
VADI	VALERIANA	DIOICA		L. =	
VAED	VALERIANA	EDULIS		NUTT. EX T. & G. =EDIBLE VALERIAN	
VAOC	VALERIANA	OCCIDENTALIS		HELL. =WESTERN VALERIAN	
VASC 2	VALERIANA	SCOULERI		RYDB. =SCOULER VALERIAN	
VASI	VALERIANA	SITCHENSIS		BONG. =SITKA VALERIAN	
VASIS	VALERIANA	SITCHENSIS	SCOULERI	PIPER =	1
VALER2	VALERIANELLA			MILL. =LAMB S-SALAD; VALERIANELLA	
VAAP	VALERIANELLA	APHANOPTERA		GRAY =	2
VACA 2	VALERIANELLA	CARINATA		LOISEL. =	
VACO 2	VALERIANELLA	CONGESTA		LINDL. =	2
VALO	VALERIANELLA	LOCUSTA		(L.) BETCKE =	
VANCO	VANCOUVERIA			MORR. & DECNE. =VANCOUVERIA (INSIDE-OUT-FLOWER)	
VACH	VANCOUVERIA	CHRYSANTHA		GREENE =YELLOW VANCOUVERIA	
VAHE	VANCOUVERIA	HEXANDRA		(HOOK.) MORR. & DEC. =WHITE VANCOUVERIA	
VAPL	VANCOUVERIA	PLANIPETALA		CALLONI. =	
VERAT	VERATRUM			L. =FALSEHELLEBORE	
VECA	VERATRUM	CALIFORNICUM		DURAND =CALIFORNIA FALSEHELLEBORE	
VECAC	VERATRUM	CALIFORNICUM	CAUDATUM	(HELLER) C. L. HITCHC. =	
VEES	VERATRUM	ESCHSCHOLTZII		GRAY =	1
VEIN	VERATRUM	INSOLITUM		JEPS. =	
VEVI	VERATRUM	VIRIDE		AIT. =AMERICAN FALSEHELLEBORE	
VERBA	VERBASCUM			L. =MULLEIN	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	C
VEBL	VERBASCUM	BLATTARIA		L.	=MOTH MULLEIN	
VETH	VERBASCUM	THAPSUS		L.	=FLANNEL MULLEIN	
VERBE	VERBENA			L.	=VERBENA	
VEBR	VERBENA	BRACTEATA		LAG. & RODR.	=	
VEHA	VERBENA	HASTATA		L.	=	
VELA	VERBENA	LASIOSTACHYS		LINK.	=	
VEPR	VERBENA	PROSTRATA		R. BR.	=	1
VEST	VERBENA	STRICTA		VENT.	=	
VERON	VERONICA			L.	=SPEEDWELL	
VEAM	VERONICA	AMERICANA		SCHWEIN. EX BENTH.	=AMERICAN SPEEDWELL	
VEAN	VERONICA	ANAGALLIS-AQUATICA		L.	=WATER SPEEDWELL	
VEAR	VERONICA	ARVENSIS		L.	=COMMON SPEEDWELL	
VEBI	VERONICA	BILOBA		L.	=	
VECA 2	VERONICA	CATENATA		PENNELL	=	
VECH	VERONICA	CHAMAEDRYS		L.	=	
VECU	VERONICA	CUSICKII		GRAY	=CUSICK SPEEDWELL	
VELO	VERONICA	LONGIFOLIA		L.	=	
VEOF	VERONICA	OFFICINALIS		L.	=	
VEPE	VERONICA	PEREGRINA		L.	=	
VEPE 2	VERONICA	PERSICA		POIR.	=	
VESC	VERONICA	SCUTELLATA		L.	=MARSH SPEEDWELL	
VESE	VERONICA	SERPYLLIFOLIA		L.	=THYMELEAF SPEEDWELL	
VESEH	VERONICA	SERPYLLIFOLIA	HUMIFUSA	(DICKS.) VAHL.	=THYMELEAF SPEEDWELL	
VEWO	VERONICA	WORMSKJOLDII		ROEM. & SCHULT.	=WORMSKJOLD SPEEDWELL	
VICIA	VICIA			L.	=VETCH	
VIAM	VICIA	AMERICANA		MUHL. EX WILLD.	=AMERICAN VETCH	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
VIAMM	VICIA	AMERICANA	MINOR	HOOK.	=	
VIAMO	VICIA	AMERICANA	OREGANA	NELS.	=OREGON AMERICAN VETCH	1
VIAMT	VICIA	AMERICANA	TRUNCATA	(NUTT.) BREW.	=BITLEAF AMERICAN VETCH	
VIAMV	VICIA	AMERICANA	VILLOSA	(KELL.) HERMANN	=	
VICA 2	VICIA	CALIFORNICA		GREENE	=CALIFORNIA VETCH	1
VICR	VICIA	CRACCA		L.	=BIRD VETCH	
VIGI	VICIA	GIGANTEA		HOOK.	=GIANT VETCH	
VIHI	VICIA	HIRSUTA		(L.) S. F. GRAY	=TINY VETCH	
VIOR	VICIA	OREGANA		NUTT.	=	1
VIPA 3	VICIA	PANNONICA		CRANTZ	=	
VISA	VICIA	SATIVA		L.	=COMMON VETCH	
VISP	VICIA	SPARSIFOLIA		NUTT. EX T. & G.	=STIFFLEAF VETCH	1
VITE	VICIA	TETRASPERMA		(L.) MOENCH	=	
VITR	VICIA	TRIFIDA		DIETR.	=CLUBLEAF VETCH	1
VITR 3	VICIA	TRUNCATA		NUTT.	=	1
VIVI	VICIA	VILLOSA		ROTH	=	
VIOLA	VIOLA			L.	=VIOLET	
VIAD	VIOLA	ADUNCA		SM.	=HOOK VIOLET	
VIADA	VIOLA	ADUNCA	ADUNCA	SM.	=	
VIADC	VIOLA	ADUNCA	CASCADENSIS	(M. S. BAKER) C. L. HITCHC.	=	
VIADU	VIOLA	ADUNCA	UNCINULATA	(GREENE) C. L. HITCHC.	=	
VIBA	VIOLA	BAKERI		GREENE	=	1
VIBE	VIOLA	BECKWITHII		T. & G.	=BECKWITH VIOLET	
VICA	VIOLA	CANADENSIS		L.	=CANADA VIOLET	
VICAR	VIOLA	CANADENSIS	RUGULOSA	(GREENE) C. L. HITCHC.	=	
VICA 4	VIOLA	CASCADENSIS		M. S. BAKER	=	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
VICU	VIOLA	CUNEATA		WATS. =WEDGELEAF VIOLET	
VIFL	VIOLA	FLAVOVIRENS		POLLARD =YELLOWGREEN VIOLET	1
VIFL 2	VIOLA	FLETTII		PIPER =	
VIGL	VIOLA	GLABELLA		NUTT. =PIONEER VIOLET	
VIHO	VIOLA	HOWELLII		GRAY =HOWELL VIOLET	
VILA 2	VIOLA	LANCEOLATA		L. =	
VILA	VIOLA	LANGSDORFII		(REGEL) FISCH. =ALEUTIAN VIOLET	
VILO	VIOLA	LOBATA		BENTH. =MOOSEHORN VIOLET	
VIMA	VIOLA	MACLOSKEYI		LLOYD =MACLOSKEY VIOLET	
VIMO	VIOLA	MONTANENSIS		RYDB. =MONTANA VIOLET	1
VINE	VIOLA	NEPHROPHYLLA		GREENE =	
VINEN	VIOLA	NEPHROPHYLLA	NEPHROPHYLLA	GREENE =	
VINUM	VIOLA	NUTTALLI	MAJOR	HOOK. =	
VINU	VIOLA	NUTTALLII		PURSH =NUTTALL VIOLET	
VINUB	VIOLA	NUTTALLII	BAKERI	(GREENE) C. L. HITCHC. =	
VINUN	VIOLA	NUTTALLII	NUTTALLII	PURSH =NUTTALL VIOLET	
VINUP	VIOLA	NUTTALLII	PRAEMORSA	(DOUGL.) WATS. =	
VINUV	VIOLA	NUTTALLII	VALLICOLA	(A. NELS.) ST. JOHN =	
VIOC	VIOLA	OCCIDENTALIS		HOWELL =SISKIYOU VIOLET	
VIOC 2	VIOLA	OCELLATA		T. & G. =PINTO VIOLET	
VIOR 2	VIOLA	ORBICULATA		GEY. EX HOOK. =DARKWOODS VETCH VIOLET	
VIPA 2	VIOLA	PALUSTRIS		L. =MARSH VIOLET	
VIPR	VIOLA	PRAEMORSA		DOUGL. EX LINDL. =CANARY VIOLET	1
VIPU	VIOLA	PURPUREA		KELL. =GOOSEFOOT VIOLET	
VIRA	VIOLA	RAFINESQUII		GREENE =RAFINESQUE VIOLET	
VIRE	VIOLA	RETROSCABRA		GREENE =CIMARRON VIOLET	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
VIRU	VIOLA	RUGULOSA		GREENE =	1
VISE	VIOLA	SEMPERVIRENS		GREENE =REDWOODS VIOLET	
VISH	VIOLA	SHELTONII		TORR. =SHELTON VIOLET	
VITR 2	VIOLA	TRINERVATA		HOW. =RAINIER VIOLET	
VIUN	VIOLA	UNCINULATA		GREENE =	1
WOLFF	WOLFFIA			HORKEL =WATER-MEAL	
WOCO	WOLFFIA	COLUMBIANA		KARST. =	
WOPU	WOLFFIA	PUNCTATA		GRISEB. =	
WOLFF2	WOLFFIELLA			HEGELM. =MUDMIDGET; WOLFFIELLA	
WOFL	WOLFFIELLA	FLORIDANA		(J. D. SMITH) THOMPSON =	
WOODS	WOODSIA			R. BR. =WOODSIA	
WOOR	WOODSIA	OREGANA		D. C. EAT. =OREGON WOODSIA	
WOSC	WOODSIA	SCOPULIA		D. C. EAT. =	
WOODW	WOODWARDIA			SM. =CHAINFERN	
WOFI	WOODWARDIA	FIMBRIATA		REES =GIANT CHAINFERN	
WYETH	WYETHIA			NUTT. =WYETHIA; MULES EARS	
WYAM	WYETHIA	AMPLEXICAULIS		NUTT. =MULES EARS WYETHIA	
WYAN	WYETHIA	ANGUSTIFOLIA		(DC.) NUTT. =NARROW LEAF WYETHIA	
WYHE	WYETHIA	HELIANTHOIDES		NUTT. =WHITE HEAD WYETHIA	
WYMO	WYETHIA	MOLLIS		GRAY =WOOLY WYETHIA	
XANTH	XANTHIUM			L. =COCKLEBUR	
XAAF	XANTHIUM	AFFINE		GREENE =	1
XASA	XANTHIUM	SACCHARATUM		WIDDER. =	
XASP	XANTHIUM	SPINOSUM		L. =SPINY COCKLEBUR	
XAST	XANTHIUM	STRUMARIUM		L. =CANADENSE	
XEROP	XEROPHYLLUM			L. C. RICH. =BEARGRASS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
XETE	XEROPHYLLUM	TENAX		(PURSH) NUTT. =COMMON BEARGRASS	
ZAUSC	ZAUSCHNERIA			PRESL. =FIRECHALICE	
ZACA	ZAUSCHNERIA	CALIFORNICA		PRESL. =CALIFCRNIA FIRE CHALICE	
ZIGAD	ZIGADENUS			L. C. RICH. =DEATH CAMAS	
ZIEL	ZIGADENUS	ELEGANS		PURSH =MCUNTAIN DEATH CAMAS	
ZIFR	ZIGADENUS	FREMONTII		TORR. =FREMONT DEATH CAMAS	
ZIGR	ZIGADENUS	GRAMINEUS		RYDB. =GRASSY DEATH CAMAS	1
ZIMI	ZIGADENUS	MICRANTHUS		EASTW. =	
ZIPA	ZIGADENUS	PANICULATUS		(NUTT.) WATS. =FOOTHILL DEATH CAMAS	
ZIVE	ZIGADENUS	VENENOSUS		WATS. =MEADOW DEATH CAMAS	
ZIVEG	ZIGADENUS	VENENOSUS	GRAMINEUS	(RYDB.) WALSH. =	
ZIVEV	ZIGADENUS	VENFNOSUS	VENENOSUS	WATS. =MEADOW DEATH CAMAS	
ZIZIA	ZIZIA			KOCH =ZIZIA	
ZIAP	ZIZIA	APTERA		(GRAY) FERN. =	
ZYGOP	ZYGOPHYLLUM			L. =BEAN-CAPER	
ZYFA	ZYGOPHYLLUM	FABAGO		L. =	

Shrubs

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SYN. CODE
AMELA	AMELANCHIER			MEDIK. =SERVICEBERRY	
AMAL	AMELANCHIER	ALNIFOLIA		NUTT. =SASKATOON SERVICEBERRY	
AMALA	AMELANCHIER	ALNIFOLIA	ALNIFOLIA	NUTT. =SASKATOON SERVICEBERRY	
AMALC	AMELANCHIER	ALNIFOLIA	CUSICKII	(FERN.) C. L. HITCHC. =	
AMALS	AMELANCHIER	ALNIFOLIA	SEMIINTEGRIFOLIA	(HOOK.) C. L. HITCHC. =	
AMCU	AMELANCHIER	CUSICKII		FERN. =CUSICK SERVICEBERRY	1
AMFL	AMELANCHIER	FLORIDA		LINDL. =	1
AMPA	AMELANCHIER	PALLIDA		GREENE =PALE SERVICEBERRY	
AMUT	AMELANCHIER	UTAHENSIS		KOEHNE =UTAH SERVICEBERRY	
ARALI	ARALIA			L. =ARALIA	
ARCTO	ARCTOSTAPHYLOS			ADANS. =MANZANITA; BEARBERRY	
ARCA 5	ARCTOSTAPHYLOS	CANESCENS		EASTW. =HOARY MANZANITA	
ARCI	ARCTOSTAPHYLOS	CINEREA		HOW. =DELNORTE MANZANITA	
ARCO 3	ARCTOSTAPHYLOS	COLUMBIANA		PIPER =HAIRY MANZANITA	
ARMA	ARCTOSTAPHYLOS	MANZANITA		PARRY =COMMON MANZANITA	
ARNE	ARCTOSTAPHYLOS	NEVADENSIS		GRAY =PINEMAT MANZANITA	
ARPAP	ARCTOSTAPHYLOS	PARRYANA	PINETORUM	(ROLL.) WIES. & SCHREIB. =PARRY MANZANITA	
ARPA	ARCTOSTAPHYLOS	PATULA		GREENE =GREENLEAF MANZANITA	
ARTO	ARCTOSTAPHYLOS	TOMENTOSA		(PURSH) LINDL. =WOOLLY MANZANITA	
ARUV	ARCTOSTAPHYLOS	UVA-URSI		(L.) SPRENG. =BEARBERRY	
ARVI	ARCTOSTAPHYLOS	VISCIDA		PARRY =WHITELEAF MANZANITA	
ARTEM	ARTEMISIA			L. =SAGEBRUSH	
ARAR	ARTEMISIA	ARBUSCULA		NUTT. =LOW SAGEBRUSH	
ARARA	ARTEMISIA	ARBUSCULA	ARBUSCULA	NUTT. =LOW SAGEBRUSH	
ARARN	ARTEMISIA	ARBUSCULA	NOVA	(A. NELS.) CRONQ. =	1
ARART	ARTEMISIA	ARBUSCULA	THERMOPOLA	BEETLE =CLEFTLEAF SAGEBRUSH	

SPP. CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
ARCA	ARTEMISIA	CANA		PURSH =SILVER SAGEBRUSH	
ARCAB	ARTEMISIA	CANA	BOLANDERI	(GRAY) WARD =BOLANDER SILVER SAGEBRUSH	
ARCAC2	ARTEMISIA	CANA	CANA	PURSH =SILVER SAGEBRUSH	
ARCAV	ARTEMISIA	CANA	VISCIDULA	OSTERH. =MOUNTAIN SILVER SAGEBRUSH	
ARFR	ARTEMISIA	FRIGIDA		WILLD. =FRINGED SAGEBRUSH	
ARLO 2	ARTEMISIA	LONGILOBA		(OSTERH.) BEETLE =EARLY LOW SAGEBRUSH	
ARNO 2	ARTEMISIA	NOVA		A. NELS. =BLACK SAGEBRUSH	1
ARPA 5	ARTEMISIA	PAPPOSA		BLAKE & CRONQ. =OWYHEE SAGEBRUSH	
ARRI	ARTEMISIA	RIGIDA		(NUTT.) GRAY =STIFF SAGEBRUSH	
ARSP	ARTEMISIA	SPINESCENS		EAT. =BUD SAGEBRUSH	
ARTR	ARTEMISIA	TRIDENTATA		NUTT. =BIG SAGEBRUSH	
ARTRS	ARTEMISIA	TRIDENTATA	SPICIFORMIS	OSTERHOUT =SUBALPINE BIG SAGEBRUSH	
ARTRT	ARTEMISIA	TRIDENTATA	TRIDENTATA	NUTT. =BASIN BIG SAGEBRUSH	
ARTRV	ARTEMISIA	TRIDENTATA	VASEYANA	(RYDB.) BEETLE =MOUNTAIN BIG SAGEBRUSH	
ARTRW	ARTEMISIA	TRIDENTATA	WYOMINGENSIS	BEETLE =WYOMING BIG SAGEBRUSH	
ARTR 2	ARTEMISIA	TRIPARTITA		RYDB. =THREETIP SAGEBRUSH	
ATRIP	ATRIPLEX			L. =SALTBRUSH; SALTBUSH; SHADSCALE	
ATCA	ATRIPLEX	CANESCENS		(PURSH) NUTT. =FOURWING SALTBUSH	
ATCO	ATRIPLEX	CONFERTIFOLIA		(TORR. & FREM.) WATS. =SHADSCALE SALTBUSH	
ATNU	ATRIPLEX	NUTTALLII		WATS. =	
ATROP	ATROPA			L. =DEADLY NIGHTSHADE; ATROPA	
ATBE	ATROPA	BELLADONNA		L. =	
BACCH	BACCHARIS			L. =BACCHARIS	
BAPI	BACCHARIS	PILULARIS		DC. =KIDNEYWORT BACCHARIS	
BAPIC	BACCHARIS	PILULARIS	CONSANGUINEA	(DC.) KUNTZE =	
BAPIP	BACCHARIS	PILULARIS	PILULARIS	DC. =KIDNEYWORT BACCHARIS	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
BERBE	BERBERIS			L. =HOLLYGRAPE; OREGON GRAPE; BARBERRY	
BEAQ	BERBERIS	AQUIFOLIUM		PURSH =OREGON HOLLYGRAPE	
BENE	BERBERIS	NERVOSA		PURSH =CASCADE HOLLYGRAPE	
BEPI	BERBERIS	PIPERIANA		(ABRAMS) MCMINN =	
BEPU	BERBERIS	PUMILA		GREENE =PYGMY HOLLYGRAPE	
BERE	BERBERIS	REPENS		LINDL. =CREEPING HOLLYGRAPE	
BEGL	BETULA	GLANDULOSA		MICHX. =BOG BIRCH	
BEGLH	BETULA	GLANDULOSA	HALLII	(HOWELL) C. L. HITCHC. =	
BEHA	BETULA	HALLII		(HOW.) HITCHC. =HALLS BIRCH	1
BEOCI	BETULA	OCCIDENTALIS	INOPINA	(JEPS.) C. L. HITCHC. =	
CASSI	CASSIOPE			D. DON =CASSIOPE; MOSS-HEATHER	
CAME	CASSIOPE	MERTENSIANA		(BONG.) G. DON =MERTENS CASSIOPE	
CAMEG	CASSIOPE	MERTENSIANA	GRACILIS	(PIPER) C. L. HITCHC. =	
CAST 5	CASSIOPE	STELLERIANA		(PALL.) DC. =	
CATE 2	CASSIOPE	TETRAGONA		(L.) D. DON =	
CATES	CASSIOPE	TETRAGONA	SAXIMONTANA	(SMALL) C. L. HITCHC. =	
CASTA	CASTANOPSIS			BLUME =CHINKAPIN; CHINQUAPIN	
CACH	CASTANOPSIS	CHRYSOPHYLLA		(DOUGL.) A. DC. =GOLDEN CHINKAPIN	
CASE	CASTANOPSIS	SEMPERVIRENS		(KELL.) DUDL. =SIERRA CHINKAPIN	
CEANO	CEANOTHUS			L. =CEANOTHUS	
CECO	CEANOTHUS	CORDULATUS		KELL. =MOUNTAIN WHITETHORN CEANOTHUS	
CECU	CEANOTHUS	CUNEATUS		(HOOK.) NUTT. EX T. & G. =BUCKBRUSH CEANOTHUS	
CEIN	CEANOTHUS	INTEGERRIMUS		H. & A. =DEERBRUSH CEANOTHUS	
CEPR	CEANOTHUS	PROSTRATUS		BENTH. =SQUAWCARPET CEANOTHUS	
CESA	CEANOTHUS	SANGUINEUS		PURSH =REDSTEM CEANOTHUS	
CETH	CEANOTHUS	THYRSIFLORUS		ESCHSCH. =BLUEBLOSSOM CEANOTHUS	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
CEVE	CEANOTHUS	VELUTINUS		DOUGL. EX HOOK. =SNOWBRUSH CEANOTHUS	
CEVEL	CEANOTHUS	VELUTINUS	LAEVIGATUS	(HOOK.) T. & G. =	
CEVEV	CEANOTHUS	VELUTINUS	VELUTINUS	DOUGL. EX HOOK. =	
CELTI	CELTIS			L. =HACKBERRY	
CERCO	CERCOCARPUS			H. =MOUNTAIN-MAHOGANY	
CEBE 2	CERCOCARPUS	BETULOIDES		NUTT. =BIRCHLEAF CERCOCARPUS	1
CEBEM	CERCOCARPUS	BETULOIDES	MACROURUS	(RYDB.) JEPS. =BIGLEAF MOUNTAIN-MAHOGANY	1
CELE	CERCOCARPUS	LEDIFOLIUS		NUTT. =CURLLEAF MOUNTAIN-MAHOGANY	
CELEI	CERCOCARPUS	LEDIFOLIUS	INTERCEDENS	C. K. SCHNEIDER =	
CELEL	CERCOCARPUS	LEDIFOLIUS	LEDIFOLIUS	NUTT. =	
CEMO	CERCOCARPUS	MONTANUS		RAF. =TRUE MOUNTAIN-MAHOGANY	
CHAMA2	CHAMAEBATIARIA			PORTER =DESERT SWEET; FERN-BUSH	
CHMI	CHAMAEBATIARIA	MILLEFOLIUM		(TORR.) MAXIM. =DESERT SWEET	
CHIMA	CHIMAPHILA			PURSH =PRINCES-PINE; PIPSISSEWA	
CHME	CHIMAPHILA	MENZIESII		(R. BR.) SPRENG. =MENZIES PRINCES-PINE	
CHUM	CHIMAPHILA	UMBELLATA		(L.) BART. =COMMON PRINCES-PINE	
CHUMO	CHIMAPHILA	UMBELLATA	OCCIDENTALIS	(RYDB.) BLAKE =WESTERN PRINCES-PINE	
CHRYS3	CHRYSOTHAMNUS			NUTT. =RABBITBRUSH	
CHNA	CHRYSOTHAMNUS	NAUSEOSUS		(PALL.) BRIT. =RUBBER RABBITBRUSH; GRAY RABBITBRUSH	
CHNAA	CHRYSOTHAMNUS	NAUSEOSUS	ALBICAULIS	(NUTT.) RYDB. =	
CHNAA2	CHRYSOTHAMNUS	NAUSEOSUS	ARTUS	(A. NELS.) CRONQ. =	
CHNAN	CHRYSOTHAMNUS	NAUSEOSUS	NANUS	CRONQ. =	
CHNAN2	CHRYSOTHAMNUS	NAUSEOSUS	NAUSEOSUS	(PALL.)BRIT. =RUBBER RABBITBRUSH	
CHNAP	CHRYSOTHAMNUS	NAUSEOSUS	PETROPHILUS	CRONQ. =GRAY RABBITBRUSH	
CHVI	CHRYSOTHAMNUS	VISCIDIFLORUS		(HOOK.) NUTT. =GREEN RABBITBRUSH	
CHVIH	CHRYSOTHAMNUS	VISCIDIFLORUS	HUMILIS	(GREENE) JEPS. =TRUCKEE GREEN RABBITBRUSH	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SC
CHVIL	CHRYSOTHAMNUS	VISCIDIFLORUS	LANCEOLATUS	(NUTT.) GREENE	=LANCELEAF GREEN RABBITBRUSH	
CHVIP	CHRYSOTHAMNUS	VISCIDIFLORUS	PUBERULUS	(D. C. EAT.) JEPS.	=DOWNY GREEN RABBITBRUSH	
CHVIP2	CHRYSOTHAMNUS	VISCIDIFLORUS	PUMILUS	(NUTT.) JEPS.	=LOW GREEN RABBITBRUSH	
CHVIS	CHRYSOTHAMNUS	VISCIDIFLORUS	STENOPHYLLUS	(GRAY) HALL	=SMALL GREEN RABBITBRUSH	
CHVIV	CHRYSOTHAMNUS	VISCIDIFLORUS	VISCIDIFLORUS	(HOOK.)NUTT.	=DOUGLAS RABBITBRUSH	
CLADO	CLADOTHAMNUS			BONG.	=CLADOTHAMNUS; COPPER-BUSH	
CLPY	CLADOTHAMNUS	PYROLAEFLORUS		BONG.	=COPPER BUSH	
CLEMA	CLEMATIS			L.	=CLEMATIS; VIRGINS-BOWER	
CLCO	CLEMATIS	COLUMBIANA		(NUTT.) T. & G.	=	
CLVEC	CLEMATIS	VERTICILLARIS	COLUMBIANA	GRAY	=COLUMBIAN ROCK CLEMATIS	1
CLVI	CLEMATIS	VITALBA		L.	=	
CORNU	CORNUS			L.	=DOGWOOD	
COGL	CORNUS	GLABRATA		BENTH.	=BROWN DOGWOOD	
CONU	CORNUS	NUTTALLI		AUD. EX T. & G.	=PACIFIC DOGWOOD	
COOC	CORNUS	OCCIDENTALIS		COV.	=WESTERN DOGWOOD	1
COST	CORNUS	STOLONIFERA		MICHX.	=RED-OSIER DOGWOOD	
COSTO	CORNUS	STOLONIFERA	OCCIDENTALIS	(T. & G.) C. L. HITCHC.	=	
COSTS	CORNUS	STOLONIFERA	STOLONIFERA	MICHX.	=RED-OSIER DOGWOOD	
CORYL	CORYLUS			L.	=HAZEL FILBERT	
COCO 2	CORYLUS	CORNUTA		MARSH.	=	
COCOC	CORYLUS	CORNUTA	CALIFORNICA	(DC.) SHARP	=CALIFORNIA HAZEL	
CRATA	CRATAEGUS			L.	=HAWTHORN	
CRCO	CRATAEGUS	COLUMBIANA		HOW.	=COLUMBIA HAWTHORN	
CRDO	CRATAEGUS	DOUGLASII		LINDL.	=BLACK HAWTHORN	
CRDOD	CRATAEGUS	DOUGLASSII	DOUGLASSII	LINDL.	=	
CRDOR	CRATAEGUS	DOUGLASSII	RIVULARIS	(NUTT.) SARG.	=	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP CCMMCN NAME	C
CRMO 2	CRATAEGUS	MONOGYNA		JACQ. =ONE-SEED HAWTHCRN	
CRRI	CRATAEGUS	RIVULARIS		NUTT. =RIVER HAWTHORN	1
CYTIS	CYTISUS			L. =BROOM	
CYMO 3	CYTISUS	MONSPESSULANUS		L. =	
CYSC	CYTISUS	SCOPARIUS		(L.) LINK =SCOTCH BROOM	
ELAEA	ELAEAGNUS			L. =ELAEAGNUS	
ELCO 2	ELAEAGNUS	CCMMJTATA		BERNH. =	
EMPET	EMPETRUM			L. =CROWBERRY	
EMNI	EMPETRUM	NIGRUM		L. =BLACK CPOWBERRY	
ERIOD	ERIODICTYON			BENTH. =YERBASANTA	
ERCA 5	ERIODICTYON	CALI=ORNICUM		(H. & A.) TORR. =CALIFCRNIA YERBASANTA	
EUONY	EUONYMUS			L. =ELONYMUS; WAHOO	
EUOC 2	EUONYMUS	OCCIDENTALIS		NUTT. EX TORR. =WESTERN WAHOO	
EUROT	EUROTIA			ADANS. =WINTERFAT	
EULA	EUROTIA	LANATA		(PURSH) MOQ. =CCMMON WINTERFAT	
FORSE	FORSELLESIA			GREENE =GREASEBUSH	2
FOSP	FORSELLESIA	SPINESCENS		(GRAY) GREENE =	2
FOST	FORSELLESIA	STIPJLIFERA		(ST.JOHN) ENSIGN =	2
FRANS2	FRANSERIA			CAV. =BURSAGE	2
FRBI	FRANSERIA	BIPINNATIFIDA		NUTT. =	2
FRAXI	FRAXINUS			L. =ASH	
FRLA 2	FRAXINUS	LATIFOLIA		BENTH. =	
FROR	FRAXINUS	OREGONA		NUTT. =OREGON ASH	1
GARRY	GARRYA			DOUGL. =SILKTASSEL	
GABU	GARRYA	BUXIFOLIA		GRAY =BCX-LEAVED GARRYA	
GAEL	GARRYA	ELLI?TICA		DOUGL. =WAVYLEAF SILKTASSEL	

CODE	GENUS NAME	SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
GAFL	GARRYA	FLAVESCENS		WATS. =	
GAFLB	GARRYA	FLAVESCENS	BUXIFOLIA	JEPS. =BOXLEAF SILKTASSEL	
GAFR	GARRYA	FREMONTII		TORR. =FREMONT SILKTASSEL	
GAULT	GAULTHERIA			L. =WINTERGREEN	
GAHI	GAULTHERIA	HISPIDULA		(L.) MUHL. =	
GAHU	GAULTHERIA	HUMIFUSA		(GRAH.) RYDB. =WESTERN WINTERGREEN	
GAOV	GAULTHERIA	OVATIFOLIA		GRAY =OREGON WINTERGREEN	
GASH	GAULTHERIA	SHALLON		PURSH =SALAL	
GLOSS	GLOSSOPETALON			GRAY =GREASEBUSH; GREENBUSH	
GLNE	GLOSSOPETALON	NEVADENSE		GRAY =SPINY GREASEBUSH	
GLNEN	GLOSSOPETALON	NEVADENSE	NEVADENSE	GRAY =SPINY GREASEBUSH	
GLNES	GLOSSOPETALON	NEVADENSE	STIPULIFERUM	(ST.JOHN) C. L. HITCHC. =	
GRAYI	GRAYIA			ENDL. =HOPSAGE	
GRSP	GRAYIA	SPINOSA		(HOOK.) MOQ. =SPINY HOPSAGE	
GUTIE	GUTIERREZIA			LAG. =SNAKEWEED; MATCHBRUSH	
GUSA	GUTIERREZIA	SAROTHRAE		(PURSH) BRITT. & RUSBY =BROOM SNAKEWEED	
HAPLO2	HAPLOPAPPUS			 =	
HABL	HAPLOPAPPUS	BLOOMERI		GRAY =RABBITBRUSH GOLDENWEED	
HAGR	HAPLOPAPPUS	GREENEI		GRAY =GREENS GOLDENWEED	
HARA	HAPLOPAPPUS	RACEMOSUS		(NUTT.) TORR. =	
HARE	HAPLOPAPPUS	RESINOSUS		(NUTT.) GRAY =	
HASU	HAPLOPAPPUS	SUFFRUTICOSUS		(NUTT.) GRAY =SINGLEHEAD GOLDENWEED	
HEDER	HEDERA			L. =IVY	
HEHE	HEDERA	HELIX		L. =	
HOLOD	HOLODISCUS			MAXIM. =ROCKSPIREA; OCEAN-SPRAY	
HODI	HOLODISCUS	DISCOLOR		(PURSH) MAXIM. =CREAMBUSH ROCKSPIREA	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
HODID	HOLODISCUS	DISCOLOR	DISCOLOR	(PURSH) MAXIM. =	
HODIG	HOLODISCUS	DISCOLOR	GLABRESCENS	(GREENM.) LAY. =	1
HODU	HOLODISCUS	DUMOSUS		(HOOK.) HELLER =BUSH ROCKSPIREA	
HODUD	HOLODISCUS	DUMOSUS	DUMOSUS	(HOOK.) HELLER =BUSH ROCKSPIREA	
HODUG	HOLODISCUS	DUMOSUS	GLABRESCENS	(GREENM.) C. L. HITCHC. =GLANDULAR ROCKSPIREA	
HOGL	HOLODISCUS	GLABRESCENS		HELLER =	1
JUNIP2	JUNIPERUS			L. =	
JUCO 4	JUNIPERUS	COMMUNIS		L. =COMMON JUNIPER	
JUCOC	JUNIPERUS	COMMUNIS	COMMUNIS	L. =COMMON JUNIPER	
JUCOS	JUNIPERUS	COMMUNIS	SAXATILIS	PALL. =MOUNTAIN COMMON JUNIPER	
JUHO 2	JUNIPERUS	HORIZONTALIS		MOENCH =	
KALMI	KALMIA			L. =KALMIA; LAUREL	
KAPO	KALMIA	POLIFOLIA		WANG. =BOG KALMIA	
KALMI2	KALMIOPSIS			REHD. =KALMIOPSIS	
KALE	KALMIOPSIS	LEACHIANA		(HENDERS.) REHD. =OREGON KALMIOPSIS	
LEDUM	LEDUM			L. =LEDUM	
LEGL	LEDUM	GLANDULOSUM		NUTT. =WESTERN LEDUM	
LEGLC	LEDUM	GLANDULOSUM	COLUMBIANUM	(PIPER) C. L. HITCHC. =COLUMBIA LEDUM	
LEGLG	LEDUM	GLANDULOSUM	GLANDULOSUM	NUTT. =WESTERN LEDUM	
LEGR	LEDUM	GROENLANDICUM		OEDER =LABRADORTEALEDUM	
LEPTO	LEPTODACTYLON			H. & A. =GRANITE GILIA; LEPTODACTYLON	
LEPU 2	LEPTODACTYLON	PUNGENS		(TORR.) NUTT. =GRANITE GILIA	
LEUCO2	LEUCOTHOE			D. DON. =LEUCOTHOE	
LEDA	LEUCOTHOE	DAVISIAE		TORR. =BLACKLAUREL LEUCOTHOE	
LIGUS2	LIGUSTRUM			L. =PRIVET	
LIVU	LIGUSTRUM	VULGARE		L. =EUROPEAN PRIVET	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	C
LITHO2	LITHOCARPUS			BLUME =TANOAK	
LIDE	LITHOCARPUS	DENSIFLORUS		(H. & A.) REHD. =TANOAK	
LOISE	LOISELEURIA			L. =ALPINE AZALEA; TRAILING AZALEA	
LOPR	LOISELEURIA	PROCUMBENS		(L.) DESV. =	
LONIC	LONICERA			L. =HONEYSUCKLE	
LOCA 3	LONICERA	CAERULEA		L. =SWEETBERRY HONEYSUCKLE	
LOCA 2	LONICERA	CAURIANA		FERN. =RED MTN.-FLY HONEYSUCKLE	1
LOCI	LONICERA	CILIOSA		(PURSH) DC. =WESTERN TRUMPET HONEYSUCKLE	
LOCO	LONICERA	CONJUGIALIS		KELL. =PURPLEFLOWER HONEYSUCKLE	
LODIG	LONICERA	DIOICA	GLAUCESCENS	L. =GLAUCOUS HONEYSUCKLE	
LOET	LONICERA	ETRUSCA		SANTI =	
LOHI	LONICERA	HISPIDULA		(LIND.) DOUGL. =	
LOHIV	LONICERA	HISPIDULA	VACILLANS	GRAY =CALIFORNIA HONEYSUCKLE	
LOIN	LONICERA	INVOLUCRATA		(RICH.) BANKS EX SPRENG. =BEARBERRY HONEYSUCKLE	
LOUT 2	LONICERA	UTAHENSIS		WATS. =UTAH HONEYSUCKLE	
LOVI	LONICERA	VILLOSA		(MICHX.) R. & S. =	
MACLU	MACLURA			NUTT. =OSAGE ORANGE	
MAPO	MACLURA	POMIFERA		(RAF.) SCHNEID. =	
MAHON	MAHONIA			NUTT. =HOLLYGRAPE	2
MAAQ	MAHONIA	AQUIFOLIUM		NUTT. =OREGON HOLLYGRAPE	2
MANE	MAHONIA	NERVOSA		NUTT. =CASCADE HOLLYGRAPE	2
MAPU	MAHONIA	PUMILA		FEDDE =PYGMY HOLLYGRAPE	2
MARE	MAHONIA	REPENS		G. DON =CREEPING HOLLYGRAPE	2
MALUS	MALUS			MILL. =APPLE; CRAB APPLE	
MADI 3	MALUS	DIVERSIFOLIA		M. ROEM. =OREGON CRAB APPLE	
MAFU	MALUS	FUSCA		SCHNEID. =	2

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
MENZI	MENZIESIA			SMITH =MENZIESIA	
MEFE	MENZIESIA	FERRUGINEA		SMITH =RUSTY MENZIESIA	
MIMUL2	MIMULUS			L. =	
MIAU	MIMULUS	AURANTIACUS		CURT. =BUSH MONKEYFLOWER	1
MORUS	MORUS			L. =MULBERRY	
MOAL	MORUS	ALBA		L. =	
MYRIC	MYRICA			L. =BAYBERRY; WAXMYRTLE; SWEETGALE	
MYCA	MYRICA	CALIFORNICA		CHAM. =PACIFIC BAYBERRY	
MYGA	MYRICA	GALE		L. =	
NOTHO	NOTHOCHELONE			GRAY =NOTHOCHELONE	
NONE	NOTHOCHELONE	NEMOROSA		(DOUGL.) STRAW =	
OPLOP	OPLOPANAX			(T. & G.) MIQ. =DEVILSCLUB	
OPHO	OPLOPANAX	HORRIDUM		(J. E. SM.) MIQ. =AMERICAN DEVILSCLUB	
OSMAR	OSMARONIA			GREENE =INDIAN PLUM; OSOBERRY	
OSCE	OSMARONIA	CERASIFORMIS		(T. & G.) GREENE =OSOBERRY	
PACHI	PACHISTIMA			RAF. =PACHISTIMA	
PAMY	PACHISTIMA	MYRSINITES		(PURSH) RAF. =MYRTLE PACHISTIMA	
PERAP	PERAPHYLLUM			NUTT. =SQUAW APPLE	
PERA 3	PERAPHYLLUM	RAMOSISSIMUM		NUTT. =SQUAWAPPLE	
PHILA	PHILADELPHUS			L. =MOCKORANGE	
PHGO	PHILADELPHUS	GORDONIANUS		LINDL. =GORDON MOCKORANGE	1
PHLE 2	PHILADELPHUS	LEWISII		PURSH =LEWIS MOCKORANGE	
PHLEG	PHILADELPHUS	LEWISII	GORDONIANUS	JEPS. =	
PHRA 3	PHILOSTEMON	RADICANS		RAF. =	2
PHYLL	PHYLLODOCE			SALISB. =MOUNTAINHEATH	
PHEM	PHYLLODOCE	EMPETRIFORMIS		(SM.) D. DON =RED MOUNTAINHEATH	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
PHGL	PHYLLODOCE	GLANDULIFLORA		(HOOK.) COV. =CREAM MOUNTAINHEATH	
PHYSO	PHYSOCARPUS			MAXIM. =NINEBARK	
PHCA 3	PHYSOCARPUS	CAPITATUS		(PURSH) KUNTZE =PACIFIC NINEBARK	
PHMA	PHYSOCARPUS	MALVACEUS		(GREENE) KUNTZE =MALLOW NINEBARK	
PHOP	PHYSOCARPUS	OPULIFOLIUS		(L.) RAF. =COMMON NINEBARK	
POTEN2	POTENTILLA			L. =	
POFR	POTENTILLA	FRUTICOSA		L. =BUSH CINQUEFOIL	
PRAV	PRUNUS	AVIUM		L. =MAZZARD CHERRY	
PRSP	PRUNUS	SPINOSA		L. =	
PURSH	PURSHIA			DC. =BITTERBRUSH	
PUTR	PURSHIA	TRIDENTATA		(PURSH) DC. =ANTELOPE BITTERBRUSH	
RHAMN	RHAMNUS			L. =BUCKTHORN; CASCARA	
RHAL 2	RHAMNUS	ALNIFOLIA		L'HER. =ALDER BUCKTHORN	
RHCA	RHAMNUS	CALIFORNICA		ESCH. =CALIFORNIA BUCKTHORN	
RHPU	RHAMNUS	PURSHIANA		DC. =CASCARA BUCKTHORN	
RHODO	RHODODENDRON			L. =RHODODENDRON; AZALEA	
RHAL	RHODODENDRON	ALBIFLORUM		HOOK. =CASCADES AZALEA	
RHMA	RHODODENDRON	MACROPHYLLUM		G. DON =PACIFIC RHODODENDRON	
RHOC	RHODODENDRON	OCCIDENTALE		(T. & G.) GRAY =WESTERN AZALEA	
RHUS	RHUS			L. =SUMAC	
RHDI	RHUS	DIVERSILOBA		T. & G. =	
RHGL	RHUS	GLABRA		L. =SMOOTH SUMAC	
RHQU	RHUS	QUERCIFOLIA		STEUD. =	
RHRA	RHUS	RADICANS		L. =	
RHTR	RHUS	TRILOBATA		NUTT. =SKUNKBRUSH SUMAC	
RIBES	RIBES			L. =CURRANT; GOOSEBERRY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
RIAC	RIBES	ACERIFOLIUM		HOWELL =MAPLELEAF CURRANT	1
RIAU	RIBES	AUREUM		PURSH =GOLDEN CURRANT	
RIBI	RIBES	BINOMINATUM		HEL. =SISKIYOU GOOSEBERRY	
RIBR	RIBES	BRACTEOSUM		DOUGL. EX HOOK. =STINK CURRANT	
RICE	RIBES	CEREUM		DOUGL. =WAX CURRANT	
RICEC	RIBES	CEREUM	CEREUM	DOUGL. =	
RICO	RIBES	COGNATUM		GREENE =UMATILLA GOOSEBERRY	
RICR	RIBES	CRUENTUM		GREENE =	
RIDI	RIBES	DIVARICATUM		DOUGL. =STRAGGLY GOOSEBERRY	
RIGO	RIBES	GOODDINGII		PECK =GOODDING GOOSEBERRY	1
RIHE	RIBES	HENDERSONII		C. L. HITCHC. =	
RIHO	RIBES	HOWELLII		GREENE =MAPLELEAF CURRANT	
RIHU	RIBES	HUDSONIANUM		RICHARDS. =HUDSONBAY CURRANT	
RIHUH	RIBES	HUDSONIANUM	HUDSONIANUM	RICHARDS. =HUDSONBAY CURRANT	
RIHUP	RIBES	HUDSONIANUM	PETIOLARE	(DOUGL.) JANCZ. =	
RIIN	RIBES	INERME		RYDB. =WHITESTEM GOOSEBERRY	
RIIR	RIBES	IRRIGUUM		DOUGL. =IDAHO GOOSEBERRY	
RIKL	RIBES	KLAMATHENSE		(COV.) FEDDE =KLAMATH GOOSEBERRY	
RILA	RIBES	LACUSTRE		(PURSH) POIR. =PRICKLY CURRANT	
RILA 2	RIBES	LAXIFLORUM		PURSH =TRAILING BLACK CURRANT	
RILO	RIBES	LOBBII		GRAY =LOBBS GOOSEBERRY	
RIMA	RIBES	MARSHALLII		GREENE =	
RIME	RIBES	MENZIESII		PURSH =MENZIES GOOSEBERRY	
RIMO 2	RIBES	MOGOLLONICUM		GREENE =	1
RIMO	RIBES	MONTIGENUM		MCCLATC. =GOOSEBERRY CURRANT	
RINI	RIBES	NIVEUM		LINDL. =SNOW GOOSEBERRY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
RIPE	RIBES	PETIOLARE		DOUGL. =WESTERN BLACK CURRANT	1
RIRE	RIBES	RENIFORME		NUTT. =	1
RIROC	RIBES	ROEZLII	CRUENTUM	REHD. =BLOOD SIERRA GOOSEBERRY	1
RISA	RIBES	SANGUINEUM		PURSH =WINTER CURRANT	
RISA 2	RIBES	SATIVUM		(REICHB.) SYME =	
RISE	RIBES	SETOSUM		LINDL. =	
RITR	RIBES	TRISTE		PALL. =	
RIVE	RIBES	VELUTINUM		GREENE =DESERT GOOSEBERRY	
RIVEG	RIBES	VELUTINUM	GOODDINGII	(PECK) C. L. HITCHC. =	
RIVEV	RIBES	VELUTINUM	VELUTINUM	GREENE =DESSERT GOOSEBERRY	
RIVI	RIBES	VISCOSISSIMUM		PURSH =STICKY CURRANT	
RIWA	RIBES	WATSONIANUM		KOEHN. =WATSON GOOSEBERRY	
RIWO	RIBES	WOLFII		ROTHROCK =	
ROSA	ROSA			L. =ROSE	
ROAC	ROSA	ACICULARIS		LINDL. ROS. =	
ROCA 2	ROSA	CANINA		L. =	
ROEG	ROSA	EGLANTERIA		L. =SWEET-BRIER	
ROGY	ROSA	GYMNOCARPA		NUTT. =BALDHIP ROSE	
RONU	ROSA	NUTKANA		PRESL. =NOOTKA ROSE	
RONUH	ROSA	NUTKANA	HISPIDA	FERN. =BRISTLY NOOTKA ROSE	
RONUN	ROSA	NUTKANA	NUTKANA	PRESL. =NOOTKA ROSE	
ROPI	ROSA	PISOCARPA		GRAY =PEAFRUIT ROSE	
ROPY	ROSA	PYRIFERA		RYDB. =PEARHIP ROSE	1
ROSP	ROSA	SPALDINGII		CREPIN =SPALDING ROSE	1
ROUL	ROSA	ULTRAMONTANA		HELLER =	1
ROWO	ROSA	WOODSII		LINDL. =WOODS ROSE	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ROWOU	ROSA	WOODSII	ULTRAMONTANA	(WATS.) JEPS. =	
ROWOW	ROSA	WOODSII	WOODSII	LINDL. =WOODS ROSE	
RUBUS	RUBUS			L. =BLACKBERRY; DEWBERRY; RASPBERRY; BRAMBLE	
RUBA	RUBUS	BARTONIANUS		PECK =	
RUHE	RUBUS	HESPERIUS		PIPER =	1
RUID	RUBUS	IDAEUS		L. =RED RASPBERRY	
RUIDI	RUBUS	IDAEUS	IDAEUS	L. =RED RASPBERRY	
RUIDS	RUBUS	IDAEUS	SACHALINENSIS	(LEVL.) FOCKE =	
RULA 2	RUBUS	LACINIATUS		WILLD. =CUTLEAF BLACKBERRY	
RULA	RUBUS	LASIOCOCCUS		GRAY =	
RULE	RUBUS	LEUCODERMIS		DOUGL. EX T. & G. =WHITEBARK RASPBERRY	
RUMA	RUBUS	MACROPETALUS		DOUGL. =TRAILING BLACKBERRY	1
RUMA 4	RUBUS	MACROPHYLLUS		WEIHE & NESS =	
RUNI 2	RUBUS	NIGERRIMUS		(GREENE) RYDB. =DARK RASPBERRY	
RUNI	RUBUS	NIVALIS		DOUGL. EX HOOK. =SNOW DEWBERRY	
RUPA	RUBUS	PARVIFLORUS		NUTT. =WESTERN THIMBLEBERRY	
RUPE	RUBUS	PEDATUS		J. E. SM. =	
RUPR	RUBUS	PROCERUS		MUELL. =	
RUPU 2	RUBUS	PUBESCENS		RAF. =	
RUSP	RUBUS	SPECTABILIS		PURSH =SALMONBERRY	
RUST	RUBUS	STRIGOSUS		MICHX. =WESTERN RED RASPBERRY	1
RUUR	RUBUS	URSINUS		CHAM. & SCHLECHT. =CALIFORNIA DEWBERRY	
RUURM	RUBUS	URSINUS	MACROPETALUS	(DOUGL.) BROWN =	
RUURU	RUBUS	URSINUS	URSINUS	CHAM. & SCHLECHT. =CALIFORNIA DEWBERRY	
RUURV	RUBUS	URSINUS	VITIFOLIUS	FOCKE =GRAPELEAF CALIFORNIA DEWBERRY	
RUVE 2	RUBUS	VESTITUS		WEIHE & NEES =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
SALIX	SALIX			L.	=WILLOW	
SAAM 2	SALIX	AMYGDALOIDES		ANDERSS.	=PEACHLEAF WILLOW	
SAAR 5	SALIX	ARCTICA		PALL.	=	
SAAR 3	SALIX	ARGOPHYLLA		NUTT.	=SILVERLEAF WILLOW	1
SABA	SALIX	BARCLAYI		ANDERSS.	=BARCLAY WILLOW	
SABE	SALIX	BEBBIANA		SARG.	=BEBB WILLOW	
SABR 2	SALIX	BRACHYCARPA		NUTT.	=	
SACA 6	SALIX	CASCADENSIS		COCKERELL	=	
SACA 5	SALIX	CAUDATA		HELLER	=WHIPLASH WILLOW	1
SACO 2	SALIX	COMMUTATA		BEBB.	=UNDERGREEN WILLOW	
SACOD	SALIX	COMMUTATA	DENUDATA	BEBB.	=	1
SACO 3	SALIX	COULTERI		ANDERSS.	=COULTER WILLOW	1
SADR	SALIX	DRUMMONDIANA		BARRATT	=	
SADRB	SALIX	DRUMMONDIANA	BELLA	BALL	=BEAUTIFUL WILLOW	1
SADRS	SALIX	DRUMMONDIANA	SUBCOERULEA	BALL	=BLUE WILLOW	1
SAEX	SALIX	EXIGUA		NUTT.	=COYOTE WILLOW	
SAEXE	SALIX	EXIGUA	EXIGUA	NUTT.	=COYOTE WILLOW	
SAEXM	SALIX	EXIGUA	MELANOPSIS	(NUTT.) CRONQ.	=	
SAFL	SALIX	FLUVIATILIS		NUTT.	=	
SAGE	SALIX	GEYERIANA		ANDERSS.	=GEYER WILLOW	
SAHO	SALIX	HOOKERIANA		BARRATT	=	
SALA 2	SALIX	LASIANDRA		BENTH.	=PACIFIC WILLOW	
SALAC	SALIX	LASIANDRA	CAUDATA	(NUTT.) SUDW.	=	
SALA 3	SALIX	LASIOLEPIS		BENTH.	=ARROYO WILLOW	
SALE	SALIX	LEMMONI		BEBB.	=LEMMONS WILLOW	
SALU	SALIX	LUTEA		NUTT.	=YELLOW WILLOW	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SAMA 2	SALIX	MACKENZIANA		BARRATT EX ANDERSS. =MACKENZIE WILLOW	1
SAME 2	SALIX	MELANOPSIS		NUTT. =DUSKY WILLOW	1
SAMO	SALIX	MONOCHROMA		BALL =GREENSIDES WILLOW	1
SAMO 2	SALIX	MONTICOLA		BEBB. EX COULT. =	
SAMY	SALIX	MYRTILLIFOLIA		ANDERSS. =BLUEBERRY WILLOW	
SANI	SALIX	NIVALIS		HOOK. =SNOW WILLOW	
SAPE 3	SALIX	PEDICELLARIS		PURSH =	
SAPE 2	SALIX	PETROPHILA		RYDB. =SKYLAND WILLOW	1
SAPH	SALIX	PHYLICIFOLIA		L. =	
SAPI	SALIX	PIPERI		BEBB =	
SAPS	SALIX	PSEUDOCORDATA		ANDERSS. =FIRMLEAF WILLOW	1
SARI	SALIX	RIGIDA		MUHL. =	
SARIM2	SALIX	RIGIDA	MACKENZIEANA	(HOOK.) CRONQ. =	
SARIM	SALIX	RIGIDA	MACROGEMMA	(BALL) CRONQ. =	
SARIW	SALIX	RIGIDA	WATSONII	(BEBB.) CRONQ. =	
SASC	SALIX	SCOULERIANA		BARRATT =SCOULER WILLOW	
SASE 2	SALIX	SESSILIFOLIA		NUTT. =	
SASI 2	SALIX	SITCHENSIS		SANSON =SITKA WILLOW	
SATW	SALIX	TWEEDYI		(BEBB.) BALL =	
SAVE	SALIX	VESTITA		PURSH =	
SAWO	SALIX	WOLFII		BEBB =	
SAWOI	SALIX	WOLFII	IDAHOENSIS	BALL =IDAHO WOLFS WILLOW	
SACA 2	SALVIA	CARNOSA		DOUGL. EX BENTH. =	1
SADO 2	SALVIA	DORRII		(KELL.) ABRAMS =	
SADOC	SALVIA	DORRII	CARNOSA	(DOUGL.) CRONQ. =DESERT SAGE	
SAPR 2	SALVIA	PRATENSIS		L. =	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
SASC 2	SALVIA	SCLAREA		L.	=	
SAMBU	SAMBUCUS			L.	=ELDER; ELDERBERRY	
SACA	SAMBUCUS	CALLICARPA		GREENE	=PACIFIC RED ELDER	1
SACE	SAMBUCUS	CERULEA		RAF.	=BLUEBERRY ELDER	
SAGL	SAMBUCUS	GLAUCA		NUTT. EX T. & G.	=BLUE ELDERBERRY	1
SAME	SAMBUCUS	MELANOCARPA		GRAY	=BLACKBEAD ELDER	1
SARA	SAMBUCUS	RACEMOSA		L.	=EUROPEAN RED ELDER	
SARAA	SAMBUCUS	RACEMOSA	ARBORESCENS	GRAY	=	
SARAA2	SAMBUCUS	RACEMOSA	ARBORESCENS	(T. & G.) GRAY	=	
SARAM	SAMBUCUS	RACEMOSA	MELANOCARPA	(GRAY) MCMINN	=	
SARAR	SAMBUCUS	RACEMOSA	RACEMOSA	L.	=EUROPEAN RED ELDER	
SARCO	SARCOBATUS			NEES	=GREASEWOOD	
SAVE 2	SARCOBATUS	VERMICULATUS		(HOOK.) TORR.	=BLACK GREASEWOOD	
SHEPH	SHEPHERDIA			NUTT.	=BUFFALOBERRY	
SHAR 2	SHEPHERDIA	ARGENTEA		(PURSH) NUTT.	=	
SHCA	SHEPHERDIA	CANADENSIS		(L.) NUTT.	=RUSSET BUFFALOBERRY	
SORBU	SORBUS			L.	=MOUNTAIN-ASH	
SOCA 2	SORBUS	CASCADENSIS		G. N. JONES	=CASCADES MOUNTAIN ASH	1
SODU	SORBUS	DUMOSA		GREENE	=ARIZONA MOUNTAIN-ASH	
SOHY	SORBUS	HYBRIDA		SCHREID.	=OAKLEAF MOUNTAIN-ASH	
SOOC	SORBUS	OCCIDENTALIS		(WATS.) GREENE	=WESTERN MOUNTAIN ASH	1
SOSA	SORBUS	SAMBUCIFOLIA		KOEHNE	=SIBERIAN MOUNTAIN-ASH	
SOSAP	SORBUS	SAMBUCIFOLIA	PUMILA	KOEHNE	=SIBERIAN MOUNTAIN-ASH	1
SOSC 2	SORBUS	SCOPULINA		GREENE	=GREENES MOUNTAIN-ASH	
SOSCC	SORBUS	SCOPULINA	CASCADENSIS	(G. N. JONES) HITCHC.	=	
SOSCS	SORBUS	SCOPULINA	SCOPULINA	GREENE	=GREENES MOUNTAIN-ASH	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	SC
SOSI	SORBUS	SITCHENSIS		ROEMER =SITKA MOUNTAIN-ASH	
SOSIG	SORBUS	SITCHENSIS	GRAYI	(WENZIG) C. L. HITCHC. =	
SPSC	SPARTIUM	SCOPARIUM		L. =	2
SPIRA	SPIRAEA			L. =SPIREA	
SPAR	SPIRAEA	ARBUSCULA		GREENE =	
SPBE	SPIRAEA	BETULIFOLIA		PALL. =	
SPBEL	SPIRAEA	BETULIFOLIA	LUCIDA	(DOUGL.) C. L. HITCHC. =	
SPDE	SPIRAEA	DENSIFLORA		NUTT. EX T. & G. =SUBALPINE SPIREA	
SPDO	SPIRAEA	DOUGLASII		HOOK. =DOUGLAS SPIREA	
SPDOD	SPIRAEA	DOUGLASII	DOUGLASII	HOOK. =DOUGLAS SPIREA	
SPDOM	SPIRAEA	DOUGLASII	MENZIESII	(HOOK.) FRESL. =	
SPDOR	SPIRAEA	DOUGLASII	ROSEATA	(RYDB.) C. L. HITCHC. =	
SPLU	SPIRAEA	LUCIDA		DOUGL. EX GREENE =SHINY LEAF SPIREA	1
SPME	SPIRAEA	MENZIESII		HOOK. =MENZIES SPIREA	1
SPMEP	SPIRAEA	MENZIESII	PYRAMIDATA	PIPER =	1
SPPI	SPIRAEA	PIKOWENSIS		BESS. =PIKOW SPIREA	
SPPY	SPIRAEA	PYRAMIDATA		GREENE =PYRAMID SPIREA	
SPRO 2	SPIRAEA	ROSEATA		RYDB. =	1
SYMPH	SYMPHORICARPOS			DUHAMEL. =SNOWBERRY	
SYAL	SYMPHORICARPOS	ALBUS		(L.) BLAKE =COMMON SNOWBERRY	
SYALA	SYMPHORICARPOS	ALBUS	ALBUS	(L.) BLAKE =COMMON SNOWBERRY	
SYALL	SYMPHORICARPOS	ALBUS	LAEVIGATUS	(FERN.) BLAKE =GARDEN CORALBERRY	
SYMO	SYMPHORICARPOS	MOLLIS		NUTT. =	
SYMOH	SYMPHORICARPOS	MOLLIS	HESPERIUS	(G. N. JONES) CRONQ. =	
SYOC	SYMPHORICARPOS	OCCIDENTALIS		HOOK. =WESTERN SNOWBERRY	
SYOR	SYMPHORICARPOS	OREOPHILUS		GRAY =MOUNTAIN SNOWBERRY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
SYRO	SYMPHORICARPOS	ROTUNDIFOLIUS		AUTHORS NOT GRAY =ROUNDLEAF SNOWBERRY	1
SYVA	SYMPHORICARPOS	VACCINIOIDES		RYDB. =WHORTLELEAF SNOWBERRY	1
TAMAR	TAMARIX			L. =TAMARISK	
TAPA	TAMARIX	PARVIFLORA		DC. =	
TETRA	TETRADYMIA			DC. =HORSEBRUSH	
TECA	TETRADYMIA	CANESCENS		DC. =GRAY HORSEBRUSH	
TECAI	TETRADYMIA	CANESCENS	INERMIS	GRAY =SPINELESS GRAY HORSEBRUSH	1
TEGL	TETRADYMIA	GLABRATA		GRAY =LITTLE-LEAF HORSEBRUSH	
TESP	TETRADYMIA	SPINOSA		H. & A. =COTTONHORN HORSEBRUSH	
TOXIC	TOXICODENDRON			L. =POISON-IVY; POISON-OAK; POISON-SUMAC	2
TODI	TOXICODENDRON	DIVERSILOBUM		GREENE =PACIFIC POISON-OAK	2
TOQU	TOXICODENDRON	QUERCIFOLIUM		GREENE =POISON-OAK	2
TORA	TOXICODENDRON	RADICANS		KUNTZE =	
TORAR	TOXICODENDRON	RADICANS	RYDBERGII	REHD. =WESTERN POISON-IVY	2
ULEX	ULEX			L. =GORSE; FURZE	
ULEU	ULEX	EUROPAEUS		L. =COMMON GORSE	
VACCI	VACCINIUM			L. =BLUEBERRY; HUCKLEBERRY; WHORTLEBERRY	
VAAL	VACCINIUM	ALASKAENSE		HOWELL =	
VACA	VACCINIUM	CAESPITOSUM		MICHX. =DWARF BLUEBERRY	
VADE	VACCINIUM	DELICIOSUM		PIPER =DELICIOUS BLUEBERRY	
VAGL	VACCINIUM	GLOBULARE		RYDB. =	
VAMA	VACCINIUM	MACROCARPON		AIT. =	
VAME	VACCINIUM	MEMBRANACEUM		DOUGL. EX HOOK. =BIG WHORTLEBERRY	
VAMY	VACCINIUM	MYRTILLUS		L. =	
VAOC 2	VACCINIUM	OCCIDENTALE		GRAY =WESTERNBOG BLUEBERRY	
VAOV	VACCINIUM	OVALIFOLIUM		SMITH =OVALLEAF WHORTLEBERRY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
VAOV 2	VACCINIUM	OVATUM		PURSH =BOX BLUEBERRY	
VAOX	VACCINIUM	OXYCOCCOS		L. =	
VAPA	VACCINIUM	PARVIFOLIUM		SMITH =RED WHORTLEBERRY	
VASC	VACCINIUM	SCOPARIUM		LEIB. =GROUSE WHORTLEBERRY	
VAUL	VACCINIUM	ULIGINOSUM		L. =	
VIBUR	VIBURNUM			L. =VIBURNUM	
VIED	VIBURNUM	EDULE		(MICHX.) RAF. =MOOSEWOOD VIBURNUM	
VIEL	VIBURNUM	ELLIPTICUM		HOOK. =OREGON VIBURNUM	
VIPA	VIBURNUM	PAUCIFLORUM		PYLAIE =	1
VITIS	VITIS			L. =GRAPE	
VICA 3	VITIS	CALIFORNICA		BENTH. =CALIFORNIA GRAPE	
VIRI	VITIS	RIPARIA		MICHX. =	
VIVI 2	VITIS	VINIFERA		L. =	
WHIPP	WHIPPLEA			TORR. =WHIPPLEA	
WHMO	WHIPPLEA	MODESTA		TORR. =MODEST WHIPPLEA	

Trees

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	SYN. CODE
ABIES	ABIES			LINK	=FIR	
ABAM	ABIES	AMABILIS		(DOUGL.) FORBES	=PACIFIC SILVER FIR	
ABCO	ABIES	CONCOLOR		(GORD. & GLEND.) LINDL. EX HILDEBR.	=WHITE FIR	
ABGR	ABIES	GRANDIS		(DOUGL.) LINDL.	=GRAND FIR	
ABLA 2	ABIES	LASIOCARPA		(HOOK.) NUTT.	=SUBALPINE FIR	
ABMA	ABIES	MAGNIFICA			=CALIFORNIA RED FIR	
ABMAS	ABIES	MAGNIFICA	SHASTENSIS	LEMM.	=SHASTA RED FIR	
ABPR	ABIES	PROCERA		REHDER	=NOBLE FIR	
ACER	ACER			L.	=MAPLE	
ACCI	ACER	CIRCINATUM		PURSH	=VINE MAPLE	
ACGL	ACER	GLABRUM		TORR.	=ROCKYMOUNTAIN MAPLE	
ACGLD	ACER	GLABRUM	DOUGLASII	(HOOK.) DIPPLE	=DOUGLAS ROCKY MOUNTAIN MAPLE	
ACGLG	ACER	GLABRUM	GLABRUM	TORR.	=ROCKYMOUNTAIN MAPLE	
ACGR 2	ACER	GRANDIDENTATUM		NUTT.	=	
ACMA	ACER	MACROPHYLLUM		PURSH	=BIGLEAF MAPLE	
ACNE	ACER	NEGUNDO		L.	=	
AESCU	AESCULUS			L.	=BUCKEYE HORSECHESTNUT	
AEHI	AESCULUS	HIPPOCASTANUM		L.	=HORSECHESTNUT	
AILAN	AILANTHUS			DESF.	=TREE-OF-HEAVEN	
AIAL	AILANTHUS	ALTISSIMA		(MILL.) SWINGLE	=	
ALNUS	ALNUS			GAERTN.	=ALDER	
ALIN	ALNUS	INCANA		(L.) MOENCH	=	
ALRH	ALNUS	RHOMBIFOLIA		NUTT.	=WHITE ALDER	
ALRU	ALNUS	RUBRA		BONG.	=RED ALDER	
ALSI	ALNUS	SINUATA		(REGEL) RYDB.	=SITKA ALDER	
ALTE	ALNUS	TENUIFOLIA		NUTT.	=THINLEAF ALDER	1

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
ARBUT	ARBUTUS			ADANS. =MADRONE	
ARME	ARBUTUS	MENZIESII		PURSH =PACIFIC MADRONE	
BETUL	BETULA			L. =BIRCH	
BEFO	BETULA	FONTINALIS		SARG. =WATER BIRCH	1
BEOC	BETULA	OCCIDENTALIS		HOOK. =WATER BIRCH	
BEOCO	BETULA	OCCIDENTALIS	OCCIDENTALIS	HOOK. =WATER BIRCH	
BEPA	BETULA	PAPYRIFERA		MARSH. =	
BEPAC	BETULA	PAPYRIFERA	COMMUTATA	(REGEL) FERN. =WESTERN PAPER BIRCH	
BEPAS	BETULA	PAPYRIFERA	SUBCORDATA	(RYDB.) SARG. =NORTHWESTERN PAPER BIRCH	
CEDO	CELTIS	DOUGLASII		PLANCH. =	
CERE 2	CELTIS	RETICULATA		TORR. =NETLEAF HACKBERRY	
CHAMA3	CHAMAECYPARIS			SPACH =FALSECYPRESS; WHITECEDAR	
CHLA	CHAMAECYPARIS	LAWSONIANA		PARL. =PORTORFORD WHITECEDAR	
CHNO	CHAMAECYPARIS	NOOTKATENSIS		(D. DON) SPACH =NOOTKA FALSECYPRESS	
CUBA	CUPRESSUS	BAKERI		JEPS. =MODOC CYPRESS	
JUNIP	JUNIPERUS			L. =JUNIPER	
JUOC	JUNIPERUS	OCCIDENTALIS		HOOK. =WESTERN JUNIPER	
JUSC	JUNIPERUS	SCOPULORUM		SARG. =ROCKY MOUNTAIN JUNIPER	
LARIX	LARIX			ADANS. =LARCH	
LALY	LARIX	LYALLI		PARL. =SUBALPINE LARCH	
LAOC	LARIX	OCCIDENTALIS		NUTT. =WESTERN LARCH	
LIBOC	LIBOCEDRUS			ENDL. =INCENSE-CEDAR	
LIDE 2	LIBOCEDRUS	DECURRENS		TORR. =	
LIDE 3	LITHOCARPUS	DENSIFLORA		(H.&A.) REHD. =TANBARK-OAK	
PETRO	PETROPHYTUM			NUTT. =ROCKMAT	
PEHE	PETROPHYTUM	HENDERSONII		(CANBY) RYDB. =HENDERSON ROCKMAT	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP	COMMON NAME	S C
PICEA	PICEA			DIETR.	=SPRUCE	
PIBR	PICEA	BREWERIANA		WATS.	=BREWER SPRUCE	
PIEN	PICEA	ENGELMANNII		PARRY EX ENGELM.	=ENGELMANN SPRUCE	
PISI	PICEA	SITCHENSIS		(BONG.) CARR.	=	
PINUS	PINUS			L.	=PINE	
PIAL	PINUS	ALBICAULIS		ENGELM.	=WHITEBARK PINE	
PIAT	PINUS	ATTENUATA		LEMM.	=KNOBCONE PINE	
PICO	PINUS	CONTORTA		DOUGL. EX LOUD.	=LODGEPOLE PINE	
PIFL	PINUS	FLEXILIS		JAMES	=	
PIJE	PINUS	JEFFERYI		GREV. & BALF.	=JEFFERY PINE	
PILA	PINUS	LAMBERTIANA		DOUGL.	=SUGAR PINE	
PIMO	PINUS	MONTICOLA		DOUGL. EX D. DON	=WESTERN WHITE PINE	
PIPO	PINUS	PONDEROSA		DOUGL. EX LOUD.	=PONDEROSA PINE	
PISY	PINUS	SYLVESTRIS		L.	=SCOTCH PINE	
POPUL	POPULUS			L.	=COTTONWOOD; POPLAR; ASPEN	
POAN 2	POPULUS	ANGUSTIFOLIA		JAMES	=	
PODE	POPULUS	DELTOIDES		MARSH.	=EASTERN COTTONWOOD	
POTR	POPULUS	TREMULOIDES		MICHX.	=QUAKING ASPEN	
POTR 2	POPULUS	TRICHOCARPA		T. & G. EX HOOK.	=BLACK COTTONWOOD	
PRUNU	PRUNUS			L.	=CHERRY; CHOKECHERRY; LAURELCHERRY; PLUM	
PRAM	PRUNUS	AMERICANA		MARSH.	=	
PREM	PRUNUS	EMARGINATA		(DOUGL.) WALPERS	=BITTER CHERRY	
PRMA	PRUNUS	MAHALEB		L.	=	
PRPR	PRUNUS	PRUNIFOLIA		SHAFER	=PLUMLEAF CHERRY	1
PRSU	PRUNUS	SUBCORDATA		BENTH.	=KLAMATH PLUM	
PRVI	PRUNUS	VIRGINIANA		L.	=COMMON CHOKECHERRY	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP COMMON NAME	S C
PRVID	PRUNUS	VIRGINIANA	DEMISSA	(NUTT.) TORR. =WESTERN CHOKECHERRY	
PRVIM	PRUNUS	VIRGINIANA	MELANOCARPA	(A. NELS.) SARG. =BLACK CHOKE CHERRY	
PRVIV	PRUNUS	VIRGINIANA	VIRGINIANA	L. =COMMON CHOKECHERRY	
PSEUD	PSEUDOTSUGA			CARR. =PSEUDO-HEMLOCK	
PSME	PSEUDOTSUGA	MENZIESII		(MIRBEL) FRANCO =DOUGLAS-FIR	
PSMEG	PSEUDOTSUGA	MENZIESII	GLAUCA	(BEISSN.) FRANCO =DOUGLAS-FIR (INTERIOR)	
PSMEM	PSEUDOTSUGA	MENZIESII	MENZIESII	(MIRBEL) FRANCO =DOUGLAS-FIR (COASTAL)	
PSTA	PSEUDOTSUGA	TAXIFOLIA		BRITT. =DOUGLAS-FIR (INTERIOR)	1
PYRUS	PYRUS			L. =PEAR; APPLE	
PYFU	PYRUS	FUSCA		RAF. =	
QUERC	QUERCUS			L. =OAK	
QUCH	QUERCUS	CHRYSOLEPIS		LIEBM. =CANYON LIVE OAK	
QUGA	QUERCUS	GARRYANA		DOUGL. =OREGON WHITE OAK	
QUKE	QUERCUS	KELLOGGII		NEWB. =CALIFORNIA BLACK OAK	
QUSA	QUERCUS	SADLERIANA		R. BR. =SADLER OAK	
QUVA	QUERCUS	VACCINIFOLIA		KELL. =HUCKLEBERRY OAK	
ROBIN	ROBINIA			L. =LOCUST; ROBINA	
ROPS	ROBINIA	PSEUDO-ACACIA		L. =BLACK LOCUST; FALSE ACACIA	
SESE 2	SEQUOIA	SEMPERVIRENS		(D.DON) ENDL. =COAST REDWOOD	
SOAU	SORBUS	AUCUPARIA		L. =	
TAXUS	TAXUS			L. =YEW	
TABR	TAXUS	BREVIFOLIA		NUTT. =PACIFIC YEW	
THUJA	THUJA			L. =THUJA; ARBORVITAE	
THPL	THUJA	PLICATA		DONN =WESTERN REDCEDAR	
TOAL	TOXICODENDRON	ALTISSIMUM		MILL. =	2
TSUGA	TSUGA			CARR. =HEMLOCK	

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP CCMMCN NAME	S C
TSHE	TSUGA	HETEROPHYLLA		(RAF.) SARG. =WESTERN HEMLOCK	
TSME	TSUGA	MERTENSIANA		(BONG.) CARR. =MCUNTAIN HEMLOCK	
UMBEL	UMBELLULARIA			NUTT. =CALIFCRNIA-LAUREL	
UMCA	UMBELLULARIA	CALIFORNICA		(H. & A.) NUTT. =CALIFCRNIA-LAUREL	

LIST OF SYNONYMS

NOTE: In this section on synonyms (pages 235-260), the first scientific plant name listed in each cluster of two or three names is the currently accepted or valid name; the second and third names are synonyms.

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
ACCOH	ACONITUM	COLUMBIANUM	HOWELLII	(NELS. / MACBR.) C. L. HITCHC.
ACHO	ACONITUM	HOWELLII		NELS. / MACBR.
ACMI	ACHILLEA	MILLEFOLIUM		L.
ACLA	ACHILLEA	LANULOSA		NUTT.
ACMIL	ACHILLEA	MILLEFOLIUM	LANULOSA	PIPER
ACRUA	ACTAEA	RUBRA	ARGUTA	(NUTT.) HULT.
ACAR	ACTAEA	ARGUTA		NUTT. EX T. / G.
ADPE	ADIANTUM	PEDATUM		L.
ADPEA	ADIANTUM	PEDATUM	ALEUTICUM	RUPR.
AGAL	AGROSTIS	ALBA		L.
AGPA	AGROSTIS	PALUSTRIS		HUDS.
AGAU	AGOSERIS	AURANTIACA		GREENE
AGGR 2	AGOSERIS	GRACILENS		KTZE.
AGCA	AGROPYRON	CANINUM		(L.) BEAUV.
AGSU	AGROPYRON	SUBSECUNDUM		A.S.HITCHC
AGCAA	AGROPYRON	CANINUM	ANDINUM	(SCRIBN. / SMITH) C. L. HITCHC.
AGSUA	AGROPYRON	SUBSECUNDUM	ANDINUM	(SCRIBN. / SM.) A.S.HITCHC.
AGCAC	AGROPYRON	CANINUM	CANINUM	(L.) BEAUV.
AGTR	AGROPYRON	TRACHYCAULUM		(LINK) MOLTE.
AGCR	AGROPYRON	CRISTATUM		(L.) GAERTN.
AGSI	AGROPYRON	SIBIRICUM		BEAUV.
AGDA	AGROPYRON	DASYSTACHYUM		(HOOK.) SCRIBN.
AGRI	AGROPYRON	RIPARIUM		SCRIBN. / SMITH
AGGL	AGOSERIS	GLAUCA		(PURSH) RAF.
AGLA	AGOSERIS	LACINIATA		GREENE
AGGLG	AGOSERIS	GLAUCA	GLAUCA	(PURSH)RAF.
AGSCA	AGOSERIS	SCORZONERAEFOLIA	ASPERA	BLAKE
AGTA	AGOSERIS	TARAXACIFOLIA		D. DIETR.
AGSC	AGROSTIS	SCABRA		WILLD.
AGHI	AGROSTIS	HIEMALIS		OF AUTHORS NOT (WALT.) B. S. P.
AGHIG	AGROSTIS	HIEMALIS	GEMINATA	A. S. HITCHC.
AGSC 2	AGROPYRON	SCRIBNERI		VASEY
AGSA	AGROPYRON	SAXICOLA		PIPER
AGSP	AGROPYRON	SPICATUM		(PURSH) SCRIBN. / SMITH
AGIN	AGROPYRON	INERME		RYDB.
AIAL	AILANTHUS	ALTISSIMA		(MILL.) SWINGLE
TOAL	TOXICODENDRON	ALTISSIMUM		MILL.
ALDO	ALLIUM	DOUGLASII		HOOK.
ALNE	ALLIUM	NEVII		WATS.
ALGRA	ALISMA	GRAMINEUM	ANGUSTISSIMUM	(DC.) HENDRICKS
ALGE 3	ALISMA	GEYERI		TORR. EX NICOLETT
ALIN	ALNUS	INCANA		(L.) MOENCH
ALTE	ALNUS	TENUIFOLIA		NUTT.
ALPA	ALLIUM	PALMERI		WATS.
ALBI	ALLIUM	BISCEPTRUM		WATS.
ALSA	ALOPECURUS	SACCATUS		VASEY
ALHO	ALOPECURUS	HOWELLII		VASEY
ALTO	ALLIUM	TOLMIEI		BAKER EX WATS.
ALANA	ALLIUM	ANCEPS	ABERRANS	M. E. JONES
ALCU	ALLIUM	CUSICKII		WATS.
AMAC	AMBROSIA	ACANTHICARPA		HOOK.
FRAC	FRANSERIA	ACANTHICARPA		(HOOK.) COVILLE

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
AMAL	AMELANCHIER	ALNIFOLIA		NUTT.
AMFL	AMELANCHIER	FLORIDA		LINDL.
AMALC	AMELANCHIER	ALNIFOLIA	CUSICKII	(FERN.) C. L. HITCHC.
AMCU	AMELANCHIER	CUSICKII		FERN.
AMBRO	AMBROSIA			L.
FRANS2	FRANSERIA			CAV.
AMCH	AMBROSIA	CHAMISSONIS		GREENE
FRBI	FRANSERIA	BIPINNATIFIDA		NUTT.
FRCH 2	FRANSERIA	CHAMISSONIS		LESS.
ANAR 2	ANGELICA	ARGUTA		NUTT.
ANLY	ANGELICA	LYALLII		WATS.
ANMU	ANEMONE	MULTIFIDA		POIR.
ANGL	ANEMONE	GLOBOSA		NUTT. EX PRITZ.
ANHU	ANEMONE	HUDSONIANA		RICHARDS.
ANRO	ANTENNARIA	ROSEA		GREENE
ANMI	ANTENNARIA	MICROCEPHALA		RYDB.
ANSP	ANTENNARIA	SPECIOSA		E. NELS.
APANP	APOCYNUM	ANDROSAEMIFOLIUM	PUMILUM	GRAY
APPU	APOCYNUM	PUMILUM		GREENE
APTO	APOCYNUM	TOMENTELLUM		GREENE
ARABI	ARABIS			L.
TURRI	TURRITIS			L.
ARAM	ARNICA	AMPLEXICAULIS		NUTT.
ARMA 2	ARNICA	MACOUNII		GREENE
ARARN	ARTEMISIA	ARBUSCULA	NOVA	(A. NELS.) CRONQ.
ARNO 2	ARTEMISIA	NOVA		A. NELS.
ARCAA	ARENARIA	CAPILLARIS	AMERICANA	(MAG.) DAVIS
ARFO 2	ARENARIA	FORMOSA		FISCH.
ARCEU	ARCEUTHOBIUM			GRISEB.
RAZOU	RAZOUMOFSKYA			JUSS.
ARCHF	ARNICA	CHAMISSONIS	FOLIOSA	(NUTT.) MAGUIRE
ARFO	ARNICA	FOLIOSA		NUTT.
ARCO 2	ARENARIA	CONGESTA		NUTT.
ARBU	ARENARIA	BURKEI		HOW.
ARDI	ARNICA	DISCOIDEA		BENTH.
ARPA 2	ARNICA	PARVIFLORA		GRAY
ARENA	ARENARIA			L.
MOEHR	MOEHRINGIA			L.
ARGL	ARABIS	GLABRA		(L.) BERNH.
TUGL	TURRITIS	GLABRA		L.
ARHI	ARABIS	HIRSUTA		(L.) SCOP.
ARPY	ARABIS	PYCNOCARPA		HOPKINS
ARKIU	ARENARIA	KINGII	UINTAHENSIS	(A. NELS.) C. L. HITCHC.
ARUI	ARENARIA	UINTAHENSIS		A. NELS.
ARLA	ARNICA	LATIFOLIA		BONG.
ARBE	ARNICA	BETONICAEFOLIA		GREENE
ARLA 2	ARENARIA	LATERIFLORA		L.
MOLA	MOEHRINGIA	LATERIFLORA		FENZL.
ARLU	ARTEMISIA	LUDOVICIANA		NUTT.
ARGN	ARTEMISIA	GNAPHALODES		NUTT.
ARMA 3	ARENARIA	MACROPHYLLA		HOOK.
MOMA	MOEHRINGIA	MACROPHYLLA		TORR.

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ARMAC	ARMERIA	MARITIMA	CALIFORNICA	(BOISS.) LAWRENCE
STARC	STATICE	ARCTICA	CALIFORNICA	BLAKE
AROB	ARENARIA	OBTUSILOBA		(RYDB.) FERN.
ARSA	ARENARIA	SAJANENSIS		AUTHORS NOT SCHLECHT.
ARPU	ARABIS	PUBERULA		NUTT.
ARSU	ARABIS	SUBPINNATIFIDA		ROLLINS
ARRY	ARNICA	RYDBERGII		GREENE
ARAU	ARNICA	AURANTIACA		GREENE
ARSP 2	ARABIS	SPARSIFLORA		NUTT.
ARPE	ARABIS	PERELEGANS		NELS.
ARSY	ARUNCUS	SYLVESTER		KOSTEL.
ARVU	ARUNCUS	VULGARIS		RAF.
ASAG	ASTRAGALUS	AGRESTIS		DOUGL. EX G.DON
ASDA	ASTRAGALUS	DASYGLOTTIS		(FISCH.) EX DC.
ASAT 2	ASTRAGALUS	ATROPUBESCENS		COULT. / FISHER
ASAR	ASTRAGALUS	ARRECTUS		GRAY
ASST	ASTRAGALUS	STENOPHYLLUS		T. / G.
ASCAM	ASTRAGALUS	CANADENSIS	MORTONI	(NUTT.) WATS.
ASMO 2	ASTRAGALUS	MORTONI		NUTT.
ASCH	ASTER	CHILENSIS		NEES
ASAD	ASTER	ADSCENDENS		LINDL.
ASCO 4	ASCLEPIAS	CORDIFOLIA		(BENTH.) JEPS.
GOCO	GOMPHOCARPUS	CORDIFOLIUS		GRAY
ASCU 2	ASTRAGALUS	CURVICARPUS		(SHELD.) MACBR.
ASSP 3	ASTRAGALUS	SPEIROCARPUS		GRAY
ASDI	ASTRAGALUS	DIAPHANUS		DOUGL. EX HOOK.
ASDI 2	ASTRAGALUS	DIURNUS		WATS.
ASFA 2	ASCLEPIAS	FASCICULARIS		DCNE.
ASME	ASCLEPIAS	MEXICANA		AUTHORS NOT CAV.
ASFI	ASTRAGALUS	FILIPES		TORR. EX GRAY
ASSTF	ASTRAGALUS	STENOPHYLLUS	FILIPES	TORR. EX GRAY
ASFO	ASTER	FOLIACEUS		LINDL.
ASCU 3	ASTER	CUSICKII		GRAY
ASKE	ASTRAGALUS	KENTROPHYTA		GRAY
ASIM	ASTRAGALUS	IMPENSUS		WOOT. / STANDL.
ASLE	ASTRAGALUS	LENTIGINOSUS		DOUGL. EX HOOK.
ASSA	ASTRAGALUS	SALINUS		HOW.
ASNE	ASTRAGALUS	NEWBERRYI		GRAY
ASWA	ASTRAGALUS	WATSONIANUS		SHELD.
ASOC	ASTER	OCCIDENTALIS		(NUTT.) T. / G.
ASFR	ASTER	FREMONTII		GRAY
ASPA 3	ASTRAGALUS	PAYSONII		(RYDB.) BARNEBY
HAPA 2	HAMOSA	PAYSONII		RYDB.
ASPUG	ASTRAGALUS	PURSHII	GLAREOSUS	(DOUGL.) BARNEBY
ASGL	ASTRAGALUS	GLAREOSUS		DOUGL. EX HOOK.
ASREC	ASTRAGALUS	REVENTUS	CONJUNCTUS	(WATS.) M. E. JONES
ASCO 3	ASTRAGALUS	CONJUNCTUS		WATS.
ASREO	ASTRAGALUS	REVENTUS	OXYTROPIDOIDES	(M. E. JONES) C. L. HITCHC.
ASHO	ASTRAGALUS	HOODIANUS		HAV.
ASRES	ASTRAGALUS	REVENTUS	SHELDONII	(RYDB.) C. L. HITCHC.
TISH	TIUM	SHELDONI		RYDB.

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ASROO	ASTRAGALUS	ROBBINSII	OCCIDENTALIS	WATS.
ASMA	ASTRAGALUS	MACOUNII		RYDB.
ASTY	ASTRAGALUS	TYGHENSIS		PECK
ASSPT	ASTRAGALUS	SPALDINGII	TYGHENSIS	(PECK) C. L. HITCHC.
ASWH	ASTRAGALUS	WHITNEYI		GRAY
ASSO	ASTRAGALUS	SONNEANUS		GREENE
ATFI	ATHYRIUM	FILIX-FEMINA		(L.) ROTH.
ATCY	ATHYRIUM	CYCLOSORUM		ATTR. TO RUPP.
BAHO	BALSAMORHIZA	HOOKERI		NUTT.
BATE	BALSAMORHIZA	TEREBINTHACEA		(HOOK.) NUTT.
BAOR	BARBAREA	ORTHOCERAS		LEDEB.
BAAM	BARBAREA	AMERICANA		RYDB.
BAVU	BARBAREA	VULGARIS		R. BR.
BAST	BARBAREA	STRICTA		AUTHORS NOT ANDRZ.
BEAQ	BERBERIS	AQUIFOLIUM		PURSH
MAAQ	MAHONIA	AQUIFOLIUM		NUTT.
BEGLH	BETULA	GLANDULOSA	HALLII	(HOWELL) C. L. HITCHC.
BEHA	BETULA	HALLII		(HOW.) HITCHC.
BENE	BERBERIS	NERVOSA		PURSH
MANE	MAHONIA	NERVOSA		NUTT.
BEOC	BETULA	OCCIDENTALIS		HOOK.
BEFO	BETULA	FONTINALIS		SARG.
BEPU	BERBERIS	PUMILA		GREENE
MAPU	MAHONIA	PUMILA		FEDDE
BERBE	BERBERIS			L.
MAHON	MAHONIA			NUTT.
BERE	BERBERIS	REPENS		LINDL.
MARE	MAHONIA	REPENS		G. DON
BERU	BESSEYA	RUBRA		(DOUGL.) RYDB.
SYRU	SYNTHYRIS	RUBRA		BENTH.
BETE	BERGIA	TEXANA		(HOOK.) SEUBERT
METE	MERIMEA	TEXANA		HOOK.
BLECH	BLECHNUM			JUSS.
PTERE	PTERETIS			RAF.
BLSP	BLECHNUM	SPICANT		(L.) WITH.
PTSP	PTERETIS	SPICANT		
BODES	BOISDUVALIA	DENSIFLORA	SALICINA	MUNZ
BOSP	BOISDUVALIA	SPARSIFLORA		HELLER
BOMA	BOYKINIA	MAJOR		GRAY
BOIN	BOYKINIA	INTERMEDIA		G.N.JONES
BOMU	BOTRYCHIUM	MULTIFIDUM		(GMEL.) TREVIS.
BOSI	BOTRYCHIUM	SILAIFOLIUM		PRESL.
BRCA	BROMUS	CARINATUS		H. / A.
BRBR 2	BROMUS	BREVIARISTATUS		THURB.
BRMA	BROMUS	MARGINATUS		NEES
BRINP	BROMUS	INERMIS	PUMPELLIANUS	(SCRIBN.) WAGNON
BRPU 2	BROMUS	PUMPELLIANUS		SCRIBN.
BRMO	BROMUS	MOLLIS		L.
BRRA	BROMUS	RACEMOSUS		L.

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BRPU	BRODIAEA	PULCHELLA		(SALISB.) GREEN
BRCA 3	BRODIAEA	CAPITATA		BENTH.
BRTE	BROMUS	TECTORUM		L.
BRTEG	BROMUS	TECTORUM	GLABRATUS	SPENNER
BRVU	BROMUS	VULGARIS		(HOOK.) SHEAR
BRLA	BROMUS	LAEVIPES		SHEAR
CAAN 2	CARDAMINE	ANGULATA		HOOK.
DEGR 2	DENTARIA	GRANDIFLORA		RAF.
CAAP 2	CASTILLEJA	APPLEGATEI		FERN.
CAPI 3	CASTILLEJA	PINETORUM		FERN.
CAAQ	CAREX	AQUATILIS		WAHL.
CASU 2	CAREX	SUBSTRICTA		MACK.
CAATA	CAREX	ATRATA	ATROSQUAMA	(MACKENZIE) CRONQ.
CAEP	CAREX	EPAPILLOSA		MACK.
CABA	CAREX	BACKII		BOOTT
CASA	CAREX	SAXIMONTANA		MACK.
CACAC	CARDAMINE	CALIFORNICA	CARDIOPHYLLA	(GREENE) DETL.
DECA 2	DENTARIA	CARDIOPHYLLA		ROB.
CACO 2	CARDAMINE	CORDIFOLIA		GRAY
CALY 2	CARDAMINE	LYALLII		WATS.
CACU 3	CASTILLEJA	CUSICKII		GREENM.
CALU 2	CASTILLEJA	LUTEA		HELL.
CADE	CAREX	DEWEYANA		SCHW.
CABO	CAREX	BOLANDERI		OLNEY
CALE 4	CAREX	LEPTOPODA		MACK.
CADR 2	CARDARIA	DRABA		(L.) DESV.
LEDR	LEPIDIUM	DRABA		L.
CAHA	CAREX	HAYDENIANA		OLNEY
CANU	CAREX	NUBICOLA		MACK.
CAHA 2	CAREX	HALLIANA		L. H. BAILEY
CAOR	CAREX	OREGONENSIS		OLNEY EX L. H. BAILEY
CALE 5	CAREX	LENTICULARIS		MICHX.
CAKE	CAREX	KELLOGGII		BOOTT
CALES	CAMASSIA	LEICHTLINII	SUKSDORFII	(GREENM.) C. L. HITCHC.
CASU	CAMASSIA	SUKSDORFII		GREENM.
CALO 2	CASTILLEJA	LONGISPICA		A. NELS.
CAPI 2	CASTILLEJA	PILOSA		(WATS.) RYDB.
CALU	CAREX	LUZULINA		OLNEY
CAAB	CAREX	ABLATA		L. H. BAILEY
CAMI	CAREX	MICROPTERA		MACK.
CAFE	CAREX	FESTIVELLA		MACK.
CAMI 2	CASTILLEJA	MINIATA		DOUGL. EX HOOK.
CACR	CASTILLEJA	CRISPULA		PIPER
CAMU	CAREX	MULTICOSTATA		MACK.
CAPA 2	CAREX	PACHYCARPA		MACK.
CAPA	CAREX	PACHYSTACHYA		CHAM.
CAPR 2	CAREX	PRESLII		STEUD.
CAPAO	CASTILLEJA	PARVIFLORA	OREOPOLA	(GREENM.) OWNBEY
CAOR 2	CASTILLEJA	OREOPOLA		GREENM.
CAPED	CAREX	PENSYLVANICA	DIGYNA	BOECK.
CAIN 4	CAREX	INOPS		L. H. BAILEY

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CAPUT	CARDAMINE	PULCHERRIMA	TENELLA	(PURSH) C. L. HITCHC.
DETE	DENTARIA	TENELLA		PURSH
CAQUA	CAMASSIA	QUAMASH	AZUREA	(HELLER) C. L. HITCHC.
QUAZ	QUAMASIA	AZUREA		HELLER
CARH	CASTILLEJA	RHEXIFOLIA		RYDB.
CALA 2	CASTILLEJA	LAUTA		A. NELS.
CARO 3	CAMPANULA	ROTUNDIFOLIA		L.
CAPE 2	CAMPANULA	PETIOLATA		A. DC.
CARU 2	CAREX	RUPESTRIS		ALLIONI
CADR	CAREX	DRUMMONDIANA		DEWEY
CASC 5	CAREX	SCOPULORUM		HOLM
CACA 3	CAREX	CAMPYLOCARPA		HOLM.
CAGY	CAREX	GYMNOCLADA		HOLM.
CASI	CAREX	SICCATA		DEWEY
CAFOT	CAREX	FOENEA	TUBERCULATA	F. J. HERM.
CASU 4	CAREX	SUBFUSCA		BOOTT
CATE	CAREX	TENERAEFORMIS		MACK.
CATO	CALOCHORTUS	TOLMIEI		H. / A.
CALO	CALOCHORTUS	LOBBII		PURDY
CAMA 3	CALOCHORTUS	MAWEANUS		LEICHTL. EX BAKER
CAVE	CAREX	VESICARIA		L.
CAEX	CAREX	EXSICCATA		L. H. BAILEY
CEAR	CERASTIUM	ARVENSE		L.
CEST	CERASTIUM	STRICTUM		L.
CEMO	CERCOCARPUS	MONTANUS		RAF.
CERE 2	CERCOCARPUS	BETULOIDES		NUTT.
CEBEM	CERCOCARPUS	BETULOIDES	MACROURUS	(RYDB.) JEPS.
CIAL	CIRCAEA	ALPINA		L.
CIPA	CIRCAEA	PACIFICA		ASCH. / MAG.
CICE	CIRSIUM	CENTAUREAE		(RYDB.) K.SCHUM.
CIAM	CIRSIUM	AMERICANUM		(GRAY) DANIELS.
CIDO	CICUTA	DOUGLASII		(DC.) COULT. / ROSE
CIVA	CICUTA	VAGANS		GREENE
CIFO	CIRSIUM	FOLIOSUM		(HOOK.) DC.
CIAC	CIRSIUM	ACAULESCENS		K.SCHUM.
CIDRA	CIRSIUM	DRUMMONDII	ACAULESCENS	MACBR.
CIPA 2	CIRSIUM	PASTORIS		J. T. HOWELL
CIOCC	CIRSIUM	OCCIDENTALE	CANDIDISSIMUM	HALL
CITH	CIRSIUM	THEEDYI		RYDB.
CIPO	CIRSIUM	POLYPHYLLUM		(RYDB.) PETR.
CIVU	CIRSIUM	VULGARE		(SAVI) AIRY-SHAW
CILA	CIRSIUM	LANCEOLATUM		HILL
CLAM	CLARKIA	AMOENA		(LEHM.) NELS. / MACBR.
GOAM	GODETIA	AMOENA		G. DON
CLAMC	CLARKIA	AMOENA	CAURINA	(ABRAMS) C. L. HITCHC.
GOCA	GODETIA	CAURINA		ABRAMS EX PIPER
CLAML	CLARKIA	AMOENA	LINDLEYI	(DOUGL.) C. L. HITCHC.
OELI	OENOTHERA	LINDLEYI		DOUGL.
CLAMP	CLARKIA	AMOENA	PACIFICA	(PECK) C. L. HITCHC.
GOPA	GODETIA	PACIFICA		PECK
CLARK	CLARKIA			PURSH
GODET	GODETIA			SPACH

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CLCO	CLEMATIS	COLUMBIANA		(NUTT.) T. / G.
CLVEC	CLEMATIS	VERTICILLARIS	COLUMBIANA	GRAY
CLGR	CLARKIA	GRACILIS		(PIPER) NELS. / MACBR.
GOGR	GODETIA	GRACILIS		PIPER
CLLAC	CLAYTONIA	LANCEOLATA	CHRYSANTHA	(GREENE) C. L. HITCHC.
CLCH 2	CLAYTONIA	CHRYSANTHA		GREENE
CLLAF	CLAYTONIA	LANCEOLATA	FLAVA	(A. NELS.) C. L. HITCHC.
CLFL	CLAYTONIA	FLAVA		A. NELS.
CLMEB	CLAYTONIA	MEGARHIZA	BELLIDIFOLIA	(RYDB.) C. L. HITCHC.
CLBE	CLAYTONIA	BELLIDIFOLIA		RYDB.
CLMEN	CLAYTONIA	MEGARHIZA	NIVALIS	(ENGLISH) C. L. HITCHC.
CLNI	CLAYTONIA	NIVALIS		ENGLISH
CLPL 2	CLEOMELLA	PLOCASPERMA		WATS.
CLOO	CLEOMELLA	OOCARPA		GRAY
CLQU	CLARKIA	QUADRIVULNERA		(DOUGL.) NELS. / MACBR.
GOQU	GODETIA	QUADRIVULNERA		SPACH
GOTE	GODETIA	TENELLA		WATS.
COCA 2	CONYZA	CANADENSIS		(L.) CRONQ.
EPCA 2	ERIGERON	CANADENSIS		L.
COCAC	CORYDALIS	CASEANA	CUSICKII	(WATS.) C. L. HITCHC.
COCU	CORYDALIS	CUSICKII		WATS.
COPA	COLLINSIA	PARVIFLORA		LINDL.
COPU	COLLINSIA	PUSILLA		HOW.
COSTO	CORNUS	STOLONIFERA	OCCIDENTALIS	(T. / G.) C. L. HITCHC.
COOC	CORNUS	OCCIDENTALIS		COV.
COSU	CONVOLVULUS	SUBACAULIS		(H. / A.) GREENE
COCA 3	CONVOLVULUS	CALIFORNICUS		CHOISY.
COTE 2	CORDYLANTHUS	TENUIS		GRAY
COPIT	CORDYLANTHUS	PILOSUS	TENUIS	JEPS.
COTI	COLLOMIA	TINCTORIA		KELL.
COAR	COLLOMIA	ARISTELLA		RYDB.
COUM	COMANDRA	UMBELLATA		(L.) NUTT.
COPA 2	COMANDRA	PALLIDA		DC.
COUMC	COMANDRA	UMBELLATA	CALIFORNICA	(EASTW.) C. L. HITCHC.
COCA 5	COMANDRA	CALIFORNICA		EASTW.
CRCI	CRYPTANTHA	CIRCUMSCISSA		(H. / A.) JOHNST.
GRCI	GREENEOCHARIS	CIRCUMSCISSA		RYDB.
CRDE	CRYPTOGRAMMA	DENSA		(BRACKENR.) DIELS IN E. / P.
CHSI	CHEILANTHES	SILIQUOSA		MAXON
CRDOR	CRATAEGUS	DOUGLASSII	RIVULARIS	(NUTT.) SARG.
CRRI	CRATAEGUS	RIVULARIS		NUTT.
CRIN 2	CRYPTANTHA	INTERMEDIA		(GRAY) GREENE
CRMU 2	CRYPTANTHA	MURICULATA		GREENE
CYAR	CYPERUS	ARISTATUS		ROTTB.
CYIN	CYPERUS	INFLEXUS		MUHL.
CYCAP	CYPRIPEDIUM	CALCEOLUS	PARVIFLORUM	(SALISB.) FERN.
CYPA	CYPRIPEDIUM	PARVIFLORUM		SALISB.
CYMOP	CYMOPTERUS			RAF.
PTERY	PTERYXIA			NUTT.
CYSC	CYTISUS	SCOPARIUS		(L.) LINK
SPSC	SPARTIUM	SCOPARIUM		L.

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CYTEF	CYMOPTERUS	TEREBINTHINUS	FOENICULACEUS	(T. / G.) CRONQ.
PTTEF	PTERYXIA	TEREBINTHINA	FOENICULACEA	MATHIAS
DEGL	DELPHINIUM	GLAUCUM		WATS.
DESCG	DELPHINIUM	SCOPULORUM	GLAUCUM	GRAY
DENUL	DELPHINIUM	NUTTALLIANUM	LINEAPETALUM	(EWAN) C. L. HITCHC.
DELI	DELPHINIUM	LINEAPETALUM		EWAN
DEPIF	DESCURAINIA	PINNATA	FILIPES	(GRAY) PECK
DELO	DESCURAINIA	LONGIPEDICELLATA		SCHULZ
DESCU	DESCURAINIA			WEBB
SOPHI	SOPHIA			L.
DESO	DESCURAINIA	SOPHIA		(L.) WEBB.
SOPA	SOPHIA	PARVIFLORA		STANDL.
DIHO	DISPORUM	HOOKERI		(TORR.) NICHOLSON
PRHO	PROSARTES	HOOKERI		TORR.
DOJE	DODECATHEON	JEFFREYI		VAN HOUTTE
DOTE	DODECATHEON	TETRANDRUM		(SUKSD.) EX GREENE
DONI	DOUGLASIA	NIVALIS		LINDL.
DODE 2	DOUGLASIA	DENTATA		WATS.
DOPAC	DODECATHEON	PAUCIFLORUM	CUSICKII	(GREENE) MASON EX ST. JOHN
DOCU	DODECATHEON	CUSICKII		GREENE
DOYI	DOWNINGIA	YINA		APPLEG.
DOWI	DOWNINGIA	WILLAMETTENSIS		PECK
DRACO	DRACOCEPHALUM			L.
MOLDA	MOLDAVICA			ADANS.
DRAN	DROSERA	ANGLICA		HUDS.
DRLO	DROSERA	LONGIFOLIA		AUTHORS NOT L.
DRDE	DRABA	DENSIFOLIA		NUTT.
DRPE	DRABA	PECTINATA		RYDB.
DRIN	DRABA	INCERTA		PAYS.
DRGL	DRABA	GLACIALIS		SENSU AM. AUTHORS NOT ADAMS
DRNU	DRACOCEPHALUM	NUTTALLII		BRITT.
DRPA	DRACOCEPHALUM	PARVIFLORUM		NUTT.
DRRE	DRABA	REPTANS		(LAM.) FERN.
DRMI	DRABA	MICRANTHA		NUTT.
DRST	DRABA	STENOLOBA		LEDEB.
DRNI	DRABA	NITIDA		GREENE
EBAU	EBUROPHYTON	AUSTINIAE		(GRAY) HELLER
CEAU	CEPHALANTHERA	AUSTINAE		GRAY
SEAU 2	SERAPIAS	AUSTINAE		EAT.
EBURO	EBUROPHYTON			HELLER
SERAP	SERAPIAS			L.
ECCR	ECHINOCHLOA	CRUSGALLI		(L.) BEAUV.
ECCRF	ECHINOCHLOA	CRUSGALLI	FRUMENTACEA	W. F. WIGHT
ELCA 2	ELYMUS	CAPUT-MEDUSAE		L.
TAAS	TAENIATHERUM	ASPERUM		(SIMONKAI) NEVSKI
ELCI	ELYMUS	CINEREUS		SCRIBN. / MERRILL
ELCO	ELYMUS	CONDENSATUS		PRESL.
ELFL	ELYMUS	FLAVESCENS		SCRIBN. / SMITH
ELAR	ELYMUS	ARENICOLA		PILGER
ELPA	ELEOCHARIS	PALUSTRIS		(L.) R. / S.
ELMA	ELEOCHARIS	MACROSTACHYA		BRITT. EX SMALL

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ELPA 2	ELEOCHARIS	PAUCIFLORA		(LIGHTF.) LINK
SCHE	SCIRPUS	HETEROCHAETUS		CHASE
SCPA	SCIRPUS	PAUCIFLORUS		LIGHTF.
ELRA	ELMERA	RACEMOSA		(WATS.) RYDB.
HERA	HEUCHERA	RACEMOSA		WATS.
ELYMU	ELYMUS			L.
TAENI	TAENIATHERUM			NEVSKI
EPAL	EPILOBIUM	ALPINUM		L.
EPHO	EPILOBIUM	HORNEMANNII		REICHB.
EPOR	EPILOBIUM	OREGONENSE		HAUSSKN.
EPALC	EPILOBIUM	ALPINUM	CLAVATUM	(TREL.) C. L. HITCHC.
EPCL	EPILOBIUM	CLAVATUM		TREL.
EPGL	EPILOBIUM	GLABERRIMUM		BARBEY
EPFA	EPILOBIUM	FASTIGIATUM		PIPER
EPGLG	EPILOBIUM	GLANDULOSUM	GLANDULOSUM	LEHM.
EPBR	EPILOBIUM	BREVISTYLUM		BARBEY
EPGLT	EPILOBIUM	GLANDULOSUM	TENUE	(TREL.) C. L. HITCHC.
EPBRU	EPILOBIUM	BREVISTYLUM	URSINUM	JEPS.
EPUR	EPILOBIUM	URSINUM		PARISH
EPPA	EPILOBIUM	PANICULATUM		NUTT. EX T. / G.
EPJU	EPILOBIUM	JUNCUNDUM		GRAY
EPWA	EPILOBIUM	WATSONII		BARBEY
EPAD	EPILOBIUM	ADENOCAULON		HAUSSKN.
EPOC	EPILOBIUM	OCCIDENTALE		RYDB.
EQHY	EQUISETUM	HYEMALE		L.
EQPR	EQUISETUM	PREALTUM		RAF.
ERAR 2	ERYSIMUM	ARENICOLA		WATS.
ERTO 2	ERYSIMUM	TORULOSUM		PIPER
ERAS	ERYSIMUM	ASPERUM		(NUTT.) DC.
ERCA 4	ERYSIMUM	CAPITATUM		GREENE
EREL 4	ERYSIMUM	ELATUM		NUTT.
ERAU	ERIGERON	AUREUS		GREENE
HABR	HAPLOPAPPUS	BRANDEGEI		GRAY
ERCOG	ERIGERON	COMPOSITUS	GLABRATUS	MACOUN
ERCOI	ERIGERON	COMPOSITUS	INCERTUS	A. NELS.
ERFL	ERIOGONUM	FLAVUM		NUTT.
ERPI	ERIOGONUM	PIPERI		GREENE
ERGR	ERYTHRONIUM	GRANDIFLORUM		PURSH
ERGRP	ERYTHRONIUM	GRANDIFLORUM	PALLIDUM	ST.JOHN
ERGRN	ERYTHRONIUM	GRANDIFLORUM	NUDIPETALUM	(APPLEGATE) C. L. HITCHC.
ERNU 2	ERYTHRONIUM	NUDOPETALUM		APPLEGATE
ERLAI	ERIOPHYLLUM	LANATUM	INTEGRIFOLIUM	(HOOK.) SMILEY
ERWA	ERIOPHYLLUM	WATSONI		GRAY
ERLI	ERIGERON	LINEARIS		(HOOK.) PIPER
ERPE 2	ERIGERON	PEUCEPHYLLUS		GRAY
ERMA 3	ERIOGONUM	MACULATUM		HELL.
ERAN 2	ERIOGONUM	ANGULOSUM		BENTH.
ERNAE	ERITRICHIUM	NANUM	ELONGATUM	(RYDB.) CRONQ.
EREL	ERITRICHIUM	ELONGATUM		WIGHT
ERNI	ERIOGONUM	NIVEUM		DOUGL. EX BENTH.
ERDI 2	ERIOGONUM	DICHOTOMUM		DOUGL.
ERPE	ERIGERON	PEREGRINUS		(PURSH) GREENE
ERSA	ERIGERON	SALSUGINOSUS		(RICH.) GRAY

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
ERPU	ERIGERON	PUMILUS		NUTT.
ERCO 2	ERIGERON	CONCINNUS		T. / G.
ERSP	ERIGERON	SPECIOSUS		(LINDL.) DC.
ERMA	ERIGERON	MACRANTHUS		NUTT.
ERST 2	ERIOGONUM	STRICTUM		BENTH.
ERPR 2	ERIOGONUM	PROLIFERUM		T. / G.
ERUM	ERIOGONUM	UMBELLATUM		TORR.
ERSP 2	ERIOGONUM	SPECIOSUM		DREW
ERSU	ERIOGONUM	SUBALPINUM		GREENE
ERTO	ERIOGONUM	TOLMIEANUM		HOOK.
ERUMS	ERIOGONUM	UMBELLATUM	STELLATUM	M. E. JONES
ERST	ERIOGONUM	STELLATUM		BENTH.
ERVIB	ERIOGONUM	VIMINEUM	BAILEYI	(WATS.) DAVIS
ERBA	ERIOGONUM	BAILEYI		WATS.
EUCR	EUPHORBIA	CRENULATA		ENGELM.
TICR	TITHYMALUS	CRENULATUS		HELLER
EUPHO	EUPHORBIA			L.
TITHY	TITHYMALUS			HALLER
FEBR	FESTUCA	BROMOIDES		L.
FEDE	FESTUCA	DERTONENSIS		(ALL.) ASCH. / GRAEBN.
FEMI	FESTUCA	MICROSTACHYS		NUTT.
FEAR 2	FESTUCA	ARIDA		ELMER
FEGR	FESTUCA	GRAYI		(ABRAMS) PIPER
FEPA	FESTUCA	PACIFICA		PIPER
FERE	FESTUCA	REFLEXA		BUCKL.
FEOV	FESTUCA	OVINA		L.
FEOVB	FESTUCA	OVINA	BRACHYPHYLLA	WATS.
FEPR	FESTUCA	PRATENSIS		HUDS.
FEEL	FESTUCA	ELATIOR		L.
FERU	FESTUCA	RUBRA		L.
FERUC	FESTUCA	RUBRA	COMMUTATA	GAUDIN
FRALN	FRASERA	ALBICAULUS	NITIDA	(BENTH.) C. L. HITCHC.
FRNI	FRASERA	NITIDA		BENTH.
FRCH	FRAGARIA	CHILOENSIS		(L.) DUCHESNE
FRCU	FRAGARIA	CUNEIFOLIA		NUTT. EX T. / G.
FRLA 2	FRAXINUS	LATIFOLIA		BENTH.
FROR	FRAXINUS	OREGONA		NUTT.
FRVEB	FRAGARIA	VESCA	BRACTEATA	(HELLER) DAVIS
FRBR	FRAGARIA	BRACTEATA		HELLER
FRVEC	FRAGARIA	VESCA	CRINITA	(RYDB.) C. L. HITCHC.
FRCA	FRAGARIA	CALIFORNICA		CHAM. / SCHLECT.
FRVIG	FRAGARIA	VIRGINIANA	GLAUCA	WATS.
FRGL	FRAGARIA	GLAUCA		RYDB.
FRVIP	FRAGARIA	VIRGINIANA	PLATYPETALA	(RYDB.) HALL
FRPL	FRAGARIA	PLATYPETALA		RYDB.
GAAPE	GALIUM	APARINE	ECHINOSPERMUM	(WALLR.) FARW.
GAVA	GALIUM	VAILLANTII		DC.
GAHU 2	GAYOPHYTUM	HUMILE		JUSS.
GAPU	GAYOPHYTUM	PUMILUM		WATS.
GANU	GAYOPHYTUM	NUTTALLII		T. / G.
GAIN	GAYOPHYTUM	INTERMEDIUM		RYDB.
GALA	GAYOPHYTUM	LASIOSPERMUM		GREENE
GANUI	GAYOPHYTUM	NUTTALLII	INTERMEDIUM	MUNZ

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GAOR	GALIUM	OREGANUM		BRITT.
GAKAO	GALIUM	KAMTSCHATICUM	OREGANUM	PIPER
GARA 2	GAYOPHYTUM	RACEMOSUM		T. / G.
GACA	GAYOPHYTUM	CAESIUM		NUTT. EX T. / G.
GEAF	GENTIANA	AFFINIS		GRISEB.
GEOR 2	GENTIANA	OREGANA		ENGELM. EX GRAY
GEAL	GEUM	ALEPPICUM		JACQ.
GEST	GEUM	STRICTUM		AIT.
GEAMA	GENTIANA	AMARELLA	ACUTA	(MICHX.) HERDER
GEAC	GENTIANA	ACUTA		MICHX.
GECA	GENTIANA	CALYCOSA		GRISEB.
GESA	GENTIANA	SAXICOLA		ENGLISH
GEMA	GEUM	MACROPHYLLUM		WILLD.
GEOR	GEUM	OREGONENSE		RYDB.
GEOR 3	GERANIUM	OREGANUM		HOWELL
GEIN	GERANIUM	INCISUM		NUTT. EX T. / G.
GEROD	GEUM	ROSSII	DEPRESSUM	(GREENE) C. L. HITCHC.
ACDE	ACOMASTYLIS	DEPRESSA		GREENE
GETR	GEUM	TRIFLORUM		PURSH
GECI	GEUM	CILIATUM		PURSH
GETRC	GEUM	TRIFLORUM	CAMPANULATUM	(GREENE) C. L. HITCHC.
GECA 2	GEUM	CAMPANULATUM		G. N. JONES
GEUM	GEUM			L.
SIEVE	SIEVERSIA			WILLD.
GIAG	GILIA	AGGREGATA		(PURSH) SPRENG.
GIPU	GILIA	PULCHELLA		DOUGL. EX HOOK.
GISI	GILIA	SINUATA		DOUGL. EX BENTH.
GIIN	GILIA	INCONSPICUA		(SM.) SWEET
GLLE 2	GLEHNIA	LEIOCARPA		MATHIAS
GLLI	GLEHNIA	LITTORALIS		SCHMIDT
GLNE	GLOSSOPETALON	NEVADENSE		GRAY
FOSP	FORSELLESIA	SPINESCENS		(GRAY) GREENE
GLNES	GLOSSOPETALON	NEVADENSE	STIPULIFERUM	(ST.JOHN) C. L. HITCHC.
FOST	FORSELLESIA	STIPULIFERA		(ST.JOHN) ENSIGN
GLOSS	GLOSSOPETALON			GRAY
FORSE	FORSELLESIA			GREENE
GOOB	GOODYERA	OBLONGIFOLIA		RAF.
GODE	GOODYERA	DECIPIENS		HUBBARD
HADIL	HABENARIA	DILATATA	LEUCOSTACHYS	(LINDL.) AMES
HALE	HABENARIA	LEUCOSTACHYS		WATS.
HAGR 2	HABENARIA	GREENEI		JEPS.
HAMA	HABENARIA	MARITIMA		GREENE
HAPLO	HAPLOPAPPUS			CASS.
APLOP	APLOPAPPUS			CASS.
HASA	HABENARIA	SACCATA		GREENE
HAST	HABENARIA	STRICTA		RYDB.
HECA	HESPEROCHIRON	CALIFORNICUS		(BENTH.) WATS.
HELA 2	HESPEROCHIRON	LASIANTHUS		ST.JOHN.
HECY	HEUCHERA	CYLINDRICA		DOUGL. EX HOOK.
HEGL	HEUCHERA	GLABELLA		WILLD. EX R. / S.

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HECYA	HEUCHERA	CYLINDRICA	ALPINA	WATS.
HEOV	HEUCHERA	OVALIFOLIA		NUTT.
HEGRT	HEUCHERA	GROSSULARIIFOLIA	TENUIFOLIA	(WHEELOCK) C. L. HITCHC.
HECYT	HEUCHERA	CYLINDRICA	TENUIFOLIA	WHEELOCK
HEHO 2	HELENIUM	HOOPESII		GRAY
DUHO	DUGALDIA	HOOPESII		RYDB.
HEPAU	HEUCHERA	PARVIFOLIA	UTAHENSIS	(RYDB.) GARRETT
HEUT	HEUCHERA	UTAHENSIS		RYDB.
HEUND	HELIANTHELLA	UNIFLORA	DOUGLASII	(T. / G.) WEBER
HEDO	HELIANTHELLA	DOUGLASII		T. / G.
HICY	HIERACIUM	CYNOGLOSSOIDES		ARV. - TOUV.
HIRY	HIERACIUM	RYDBERGII		ZAHN
HISC	HIERACIUM	SCOULERI		HOOK.
HICH	HIERACIUM	CHAPACANUM		ZAHN
HOBR	HORDEUM	BRACHYANTHERUM		NEVSKI
HONOB	HORDEUM	NODOSUM	BOREALE	A. S. HITCHC.
HODA	HORKELIA	DAUCIFOLIA		(GREENE) RYDB.
HOCA 2	HORKELIA	CARUIFOLIA		RYDB.
HODE 2	HORDEUM	DEPRESSUM		(SCRIBN. / SM.) RYDB.
HONO	HORDEUM	NODOSUM		AUTHORS NOT L.
HODUG	HOLODISCUS	DUMOSUS	GLABRESCENS	(GREENM.) C. L. HITCHC.
HODIG	HOLODISCUS	DISCOLOR	GLABRESCENS	(GREENM.) LAY.
HOGL	HOLODISCUS	GLABRESCENS		HELLER
HOFUC	HORKELIA	FUSCA	CAPITATA	(LINDL.) PECK
HOCA	HORKELIA	CAPITATA		LINDL.
HOFUT	HORKELIA	FUSCA	TENELLA	WATS.
HOTE	HORKELIA	TENELLA		RYDB.
HOGE	HORDEUM	GENICULATUM		ALLIONI
HOGU	HORDEUM	GUSSONIANUM		PARL.
HYFOS	HYPERICUM	FORMOSUM	SCOULERI	(HOOK.) C. L. HITCHC.
HYSC	HYPERICUM	SCOULERI		HOOK.
HYMO	HYPOPITYS	MONOTROPA		CRANTZ.
HYLA	HYPOPITYS	LATISQUAMA		RYDB.
HYMU	HYPOPITYS	MULTIFLORA		DC.
IDAHO	IDAHOA			NELS. / MACBR.
PLATY	PLATYSPERMUM			HOOK.
IDSC	IDAHOA	SCAPIGERA		(HOOK.) NELS. / MACBR.
PLSC	PLATYSPERMUM	SCAPIGERUM		HOOK.
ILLO	ILIAMNA	LONGISEPALA		(TORR.) WIGG.
SPLO	SPHAERALCEA	LONGISEPALA		TORR.
ILRI	ILIAMNA	RIVULARIS		(DOUGL.) GREENE
SPRI	SPHAERALCEA	RIVULARIS		TORR. EX GRAY
JUEFG	JUNCUS	EFFUSUS	GRACILIS	HOOK.
JUEFB	JUNCUS	EFFUSUS	BRUNNEUS	ENGELM.
JUEN	JUNCUS	ENSIFOLIUS		WILSK.
JUSA	JUNCUS	SAXIMONTANUS		A. NELS.
JUNE	JUNCUS	NEVADENSIS		WATS.
JUMES	JUNCUS	MERTENSIANUS	SUKSDORFII	F. J. HERM.
JUNEB	JUNCUS	NEVADENSIS	BADIUS	(SUKSD.) C. L. HITCHC.
JUBA 2	JUNCUS	BADIUS		SUKSD.

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JUSU	JUNCUS	SUPINIFORMIS		ENGELM.
JUOR 2	JUNCUS	OREGANUS		WATS.
JUTE	JUNCUS	TENUIS		WILLD.
JUDU	JUNCUS	DUDLEYI		WIEG.
JUOC 2	JUNCUS	OCCIDENTALIS		WIEG.
LABI	LATHYRUS	BIJUGATUS		WHITE
LABIS	LATHYRUS	BIJUGATUS	SANDBERGII	WHITE
LABI 2	LACTUCA	BIENNIS		(MOENCH.) FERN.
LASP	LACTUCA	SPICATA		HITCHC.
LALAL	LATHYRUS	LANSZWERTII	LANSZWERTII	KELL.
LAOR	LATHYRUS	OREGONENSIS		WHITE
LAMIM	LASTHENIA	MINOR	MARITIMA	(GRAY) CRONQ.
BAMA	BAERIA	MARITIMA		GRAY
LANEC	LATHYRUS	NEVADENSIS	CUSICKII	(WATS.) C. L. HITCHC.
LACU	LATHYRUS	CUSICKII		WATS.
LANEL	LATHYRUS	NEVADENSIS	LANCEOLATUS	(HOW.) C. L. HITCHC.
LALA	LATHYRUS	LANCEOLATUS		HOWELL
LANU	LATHYRUS	NUTTALLII		WATS.
LAOC 2	LATHYRUS	OCHROLEUCUS		HOOK.
LAOB	LATHYRUS	OBOVATUS		WHITE
LAPA 2	LATHYRUS	PAUCIFLORUS		FERN.
LAPAT	LATHYRUS	PAUCIFLORUS	TENUIOR	PECK
LELU	LESQUERELLA	LUDOVICIANA		(NUTT.) WATS.
LEAR	LESQUERELLA	ARGENTEA		MACMILLAN
LEPY	LEWISIA	PYGMAEA		(GRAY) ROBINS.
LENE	LEWISIA	NEVADENSIS		ROBINS.
LEPY 2	LEPTARRHENA	PYROLIFOLIA		(D. DON) R. BR.
LEAM	LEPTARRHENA	AMPLEXIFOLIA		R. BR. EX SER.
LEVI	LEPIDIUM	VIRGINICUM		L.
LEME 2	LEPIDIUM	MEDIUM		GREENE
LIBOL	LINNAEA	BOREALIS	LONGIFLORA	TORR.
LIBOA	LINNAEA	BOREALIS	AMERICANA	REHD.
LIGR	LIGUSTICUM	GRAYI		COULT. / ROSE
LICU	LIGUSTICUM	CUSICKII		COULT. / ROSE
LIPU	LIGUSTICUM	PURPUREUM		COULT. / ROSE
LINU	LINANTHASTRUM	NUTTALLII		(GRAY) EWAN
GINU	GILIA	NUTTALLII		GRAY
LIPE	LINUM	PERENNE		L.
LILE	LINUM	LEWISII		PURSH
LITE 2	LIGUSTICUM	TENUIFOLIUM		WATS.
LIFIT	LIGUSTICUM	FILICINUM	TENUIFOLIUM	MATH. / CONST.
LOCA 3	LONICERA	CAERULEA		L.
LOCA 2	LONICERA	CAURIANA		FERN.
LOCO 4	LOMATIUM	COLUMBIANUM		MATH. / CONST.
LEPU	LEPTOTAENIA	PURPUREA		COULT. / ROSE
LODE	LOTUS	DENTICULATUS		(DREW) GREENE
HODE	HOSACKIA	DENTICULATA		DREW
LODID	LOMATIUM	DISSECTUM	DISSECTUM	(NUTT.) MATH. / CONST.
LEDI	LEPTOTAENIA	DISSECTA		NUTT.
LEMU	LEPTOTAENIA	MULTIFIDA		NUTT.
LOGO	LOMATIUM	GORMANII		(HOWELL) COULT. / ROSE
LOPI	LOMATIUM	PIPERI		COULT. / ROSE

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LOMA 2	LOMATIUM	MARTINDALEI		COULT. / ROSE
LOAN	LOMATIUM	ANGUSTATUM		ST.JOHN.
LOMAT	LOMATIUM			RAF.
LEPTO2	LEPTOTAENIA			NUTT.
LONE 2	LOTUS	NEVADENSIS		(WATS.) GREENE
LODO 2	LOTUS	DOUGLASII		GREENE
LOPI 2	LOTUS	PINNATUS		HOOK.
LOBI	LOTUS	BICOLOR		DOUGL. EX BENTH.
LOPU	LOTUS	PURSHIANUS		(BENTH.) C. / C.
LOAM 2	LOTUS	AMERICANUS		BISCH.
LOTRT	LOMATIUM	TRITERNATUM	TRITERNATUM	(PURSH) COULT. / ROSE
LOSI	LOMATIUM	SIMPLEX		MACBR.
LOTRM	LOMATIUM	TRITERNATUM	MACROCARPUM	(COULT. / ROSE) MATH.
LUAL	LUPINUS	ALBICAULIS		DOUGL. EX HOOK.
LUAN	LUPINUS	ANDERSONI		WATS.
LUARA2	LUPINUS	ARGENTEUS	ARGENTEUS	PURSH
LUCAR	LUPINUS	CAUDATUS	RUBRICAULIS	C. P. SM.
LUCO 2	LUPINUS	CORYMBOSUS		HELLER
LUARP	LUPINUS	ARGENTEUS	PARVIFLORUS	(NUTT.) C. L. HITCHC.
LUPA 2	LUPINUS	PARVIFLORUS		NUTT. EX H. / A.
LUCA 2	LUZULA	CAMPESTRIS		(L.) DC.
LUCO	LUZULA	COMOSA		E. MEY.
LUMUC2	LUZULA	MULTIFLORA	COMOSA	ST.JOHN.
LUSU 4	LUZULA	SUBSESSILIS		BUCH.
LUCAM	LUZULA	CAMPESTRIS	MULTIFLORA	(EHRH.) CELAK.
LUMU	LUZULA	MULTIFLORA		LEJEUNE
LUINA	LUINA			BENTH.
RAINI	RAINIERA			GREENE
LULAL2	LUPINUS	LATIFOLIUS	LATIFOLIUS	AGARDH.
LULAC	LUPINUS	LATIFOLIUS	COLUMBIANUS	(HELLER) C. P. SM.
LULAL3	LUPINUS	LAXIFLORUS	LAXIFLORUS	DOUGL. EX LINDL.
LULAC3	LUPINUS	LAXIFLORUS	COGNATUS	C. P. SM.
LULAS2	LUPINUS	LAXIFLORUS	SILVICOLA	(HELLER) C. P. SM.
LULAP	LUPINUS	LAXIFLORUS	PSEUDOPARVIFLORUS	(RYDB.) SM. / ST.JOHN.
LUPS	LUPINUS	PSEUDOPARVIFLORUS		RYDB.
LUSC	LUPINUS	SCHEUBERAE		RYDB.
LULAS	LUPINUS	LATIFOLIUS	SUBALPINUS	(PIPER / ROBINS.) C. P. SM.
LUSU 3	LUPINUS	SUBALPINUS		PIPER / ROBINS
LULAT	LUPINUS	LATIFOLIUS	THOMPSONIANUS	(C. P. SM.) C. L. HITCHC.
LUSU 2	LUPINUS	SUKSDORFII		ROBINS EX PIPER
LULE 2	LUPINUS	LEPIDUS		DOUGL.
LUMI 3	LUPINUS	MINIMUS		DOUGL. EX HOOK.
LULEA	LUPINUS	LEPIDUS	ARIDUS	(DOUGL.) JEPS.
LUAR 2	LUPINUS	ARIDUS		DOUGL. EX LINDL.
LULEC2	LUPINUS	LEPIDUS	CUSICKII	(WATS.) C. L. HITCHC.
LUARA	LUPINUS	ARIDUS	ABORTIVUS	C. P. SM.
LUARC	LUPINUS	ARIDUS	CUSICKII	C. P. SM.
LULEL	LUPINUS	LEUCOPHYLLUS	LEUCOPHYLLUS	DOUGL. EX LINDL.
LULEB	LUPINUS	LEUCOPHYLLUS	BELLIAE	C. P. SM.
LULEC	LUPINUS	LEUCOPHYLLUS	CANESCENS	(HOW.) C. P. SM.
LULEL2	LUPINUS	LEPIDUS	LOBBII	(GRAY) C. L. HITCHC.
LUART	LUPINUS	ARIDUS	TORREYI	C. P. SM.
LULY	LUPINUS	LYALLII		GRAY
LULYL	LUPINUS	LYALLII	LOBBII	C. P. SM.

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LUMIM	LUPINUS	MICROCARPUS	MICROCARPUS	SIMS
LUSUT	LUPINUS	SUBVEXUS	TRANSMONTANUS	C. P. SM.
LUNA 2	LUINA	NARDOSMIA		(GRAY) CRONQ.
CANA	CACALIOPSIS	NARDOSMIA		GRAY
LUPA	LUZULA	PARVIFLORA		(EHRH.) DESV.
LUPI	LUZULA	PIPERI		(COV.) M. E. JONES
LUPOB	LUPINUS	POLYPHYLLUS	BURKEI	(WATS.) C. L. HITCHC.
LUBU	LUPINUS	BURKEI		WATS.
LUSUB	LUPINUS	SUPERBUS	BERNARDINUS	ABRAMS EX C. P. SM.
LUSES	LUPINUS	SERICEUS	SERICEUS	PURSH
LUOR	LUPINUS	ORNATUS		DOUGL. EX LINDL.
LUST	LUINA	STRICTA		(GREENE) ROB.
RAST	RAINIERA	STRICTA		GREENE
LYSIM	LYSIMACHIA			L.
STEIR	STEIRONEMA			RAF.
MACA	MACHAEROCARPUS	CALIFORNICUS		(TORR.) SMALL
DACA 2	DAMASONIUM	CALIFORNICUM		TORR.
MACA 2	MACHAERANTHERA	CANESCENS		(PURSH) GRAY.
ASCA	ASTER	CANESCENS		PURSH
MACAT	MACHAERANTHERA	CANESCENS	TEPHRODES	(GRAY) GREENE
ASTE 5	ASTER	TEPHRODES		BLAKE
MADIA	MADIA			MOLINA
HEMIZ2	HEMIZONELLA			GRAY
MAGR	MADIA	GRACILIS		(SMITH) KECK
MADI	MADIA	DISSITIFLORA		T. / G.
MALA 2	MACHAERANTHERA	LAETEVIRENS		GREENE
ASLE 5	ASTER	LEIODES		BLAKE
MAMI	MADIA	MINIMA		(GRAY) KECK
HEMI 2	HEMIZONELLA	MINIMA		GRAY
MAOR	MARAH	OREGANUS		(T. / G.) HOWELL
MEOR	MEGARRHIZA	OREGANA		TORR. EX WATS.
MASHS2	MACHAERANTHERA	SHASTENSIS	SHASTENSIS	GRAY
ASSH	ASTER	SHASTENSIS		GRAY
MEAR 3	MENTHA	ARVENSIS		L.
MEARC	MENTHA	ARVENSIS	CANADENSIS	KUNTZE
MECA	MENTHA	CANADENSIS		L.
MELAL	MENTZELIA	LAEVICAULIS	LAEVICAULIS	(DOUGL.) T. / G.
MEAC	MENTZELIA	ACUMINATA		TIDESTROM.
MEOB	MERTENSIA	OBLIGIFOLIA		(NUTT.) G. DON
MEUM	MERTENSIA	UMBRATILIS		GREENM.
MESU	MELICA	SUBULATA		(GRISEB.) SCRIBN.
FESU	FESTUCA	SUBULATA		TRIN.
MIAL 2	MICROSERIS	ALPESTRIS		(GRAY) Q. JONES
AGAL 2	AGOSERIS	ALPESTRIS		GREENE
MIGR	MICROSTERIS	GRACILIS		(HOOK.) GREENE
MIHU	MICROSTERIS	HUMILIS		GREENE
PHGR	PHLOX	GRACILIS		GREENE
MIGRH	MICROSTERIS	GRACILIS	HUMILIOR	(HOOK.) CRONQ.
MIMI	MICROSTERIS	MICRANTHA		GREENE
MIGU	MIMULUS	GUTTATUS		DC.
MIMI 2	MIMULUS	MICROPHYLLUS		BENTH.
MINA 2	MIMULUS	NASUTUS		GREENE
MISC	MIMULUS	SCOULERI		HOOK.

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
MILI 2	MICROSERIS	LINDLEYI		DC.
MILI	MICROSERIS	LINEARIFOLIA		(NUTT.) SCHULTZ - BIP.
MIST 2	MITELLA	STAUROPETALA		PIPER
MIST	MITELLA	STENOPETALA		PIPER
MISU	MIMULUS	SUKSDORFII		GRAY
MIAU	MIMULUS	AURANTIACUS		CURT.
MITI	MIMULUS	TILINGII		REGEL
MIIM	MIMULUS	IMPLEXUS		GREENE
MILUA	MIMULUS	LUTEUS	ALPINUS	GRAY
MOAR	MONTIA	ARENICOLA		(HENDERS.) HOW.
CLAR	CLAYTONIA	ARENICOLA		HENDERS.
MOCH	MONTIA	CHAMISSOI		(LEDEB.) ROBBINS / FERN.
CLCH	CLAYTONIA	CHAMISSOI		LEDEB. EX SPRENG.
MOCO	MONTIA	CORDIFOLIA		(WATS.) PAX / K. HOFFM.
CLAS	CLAYTONIA	ASARIFOLIA		GRAY
CLCO 2	CLAYTONIA	CORDIFOLIA		WATS.
MODI	MONTIA	DICHOTOMA		(NUTT.) HOW.
CLDI	CLAYTONIA	DICHOTOMA		NUTT.
MOOD	MONARDELLA	ODORATISSIMA		BENTH.
MONE	MONARDELLA	NERVOSA		GREENE
MOODD	MONARDELLA	ODORATISSIMA	DISCOLOR	(GREENE) ST.JOHN.
MODI 2	MONARDELLA	DISCOLOR		GREENE
MOPA	MONTIA	PARVIFOLIA		(MOC.) GREENE
CLPA	CLAYTONIA	PARVIFOLIA		MOQ.
MOPE	MONTIA	PERFOLIATA		(DONN) HOW.
CLPE	CLAYTONIA	PERFOLIATA		DONN
CLRU	CLAYTONIA	RUBRA		TIDESTR.
MOSI	MONTIA	SIBIRICA		(L.) HOW.
CLSI	CLAYTONIA	SIBIRICA		L.
MOSP	MONTIA	SPATHULATA		(DOUGL.) HOW.
CLSP	CLAYTONIA	SPATHULATA		DOUGL.
MUMI	MUHLENBERGIA	MINUTISSIMA		(STEUD.) SWALLEN
SPMI	SPOROBOLUS	MICROSPERMUS		A. S. HITCHC.
MURA	MUHLENBERGIA	RACEMOSA		(MICHX.) B. S. P.
AGRA	AGROSTIS	RACEMOSA		MICHX.
MUGL	MUHLENBERGIA	GLOMERATA		TRIN.
POGL 5	POLYPOGON	GLOMERATUS		WILLD.
MURI	MUHLENBERGIA	RICHARDSONIS		(TRIN.) RYDB.
MUSQ	MUHLENBERGIA	SQUARROSA		RYDB.
NABR	NAVARRETIA	BREWERI		(GRAY) GREENE
GIBR	GILIA	BREWERI		GRAY
NATA	NAVARRETIA	TAGETINA		GREENE
NAKL	NAVARRETIA	KLICKITATENSIS		SUKSD.
NEPA	NEMOPHILA	PARVIFLORA		DOUGL. EX BENTH.
NEIN	NEMOPHILA	INCONSPICUA		HENDERS.
NEPE	NEMOPHILA	PEDUNCULATA		DOUGL. EX BENTH.
NEDE	NEMOPHILA	DENSA		HOWELL
NESE	NEMOPHILA	SEPULTA		PARISH
NONE	NOTHOCHELONE	NEMOROSA		(DOUGL.) STRAW
PENE 2	PENSTEMON	NEMOROSUS		(DOUGL.) TRAUTV.
NUPO	NUPHAR	POLYSEPALA		ENGELM.
NYPO	NYMPHAEA	POLYSEPALA		GREENE

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OEBI	OENOTHERA	BIENNIS		L.
OERY	OENOTHERA	RYDBERGII		HOUSE
OESA	OENANTHE	SARMENTOSA		PRESL. EX DC.
OECA	OENANTHE	CALIFORNICA		WATS.
OPERX	OPUNTIA	ERINACEA	XANTHOSTEMMA	(K. SCHUM.) BENS.
OPRH	OPUNTIA	RHODANTHA		K. SCHUM.
ORCOC	ORTHOCARPUS	COPELANDII	CRYPTANTHUS	(PIPER) KECK
ORCR	ORTHOCARPUS	CRYPTANTHUS		PIPER
ORFA 2	OROBANCHE	FASCICULATA		NUTT.
THFA	THALESIA	FASCICULATA		BRITT.
OROBA	OROBANCHE			L.
THALE	THALESIA			RAF.
ORUN	OROBANCHE	UNIFLORA		L.
THUN	THALESIA	UNIFLORA		BRITT.
OSCH	OSMORHIZA	CHILENSIS		H. / A.
OSBR	OSMORHIZA	BREVIPES		SUKSD.
OSDI	OSMORHIZA	DIVARICATA		NUTT. EX T. / G.
OSNU	OSMORHIZA	NUDA		TORR.
OXBEB	OXYTROPIS	BESSEYI	BESSEYI	(RYDB.) BLANK.
ARBE 2	ARAGALLUS	BESSEYI		RYDB.
OXCAG	OXYTROPIS	CAMPESTRIS	GRACILIS	(A. NELS.) BARNEBY
OXLU	OXYTROPIS	LUTEOLA		PIPER / BEATTIE
PAOC 2	PANICUM	OCCIDENTALE		SCRIBN.
PAPA 2	PANICUM	PACIFICUM		HITCHC. / CHASE
PAPA	PARNASSIA	PALUSTRIS		L.
PACA 2	PARNASSIA	CALIFORNICA		GREENE
PEATP	PENSTEMON	ATTENUATUS	PSEUDOPROCERUS	(RYDB.) CRONQ.
PEPS	PENSTEMON	PSEUDOPROCERUS		RYDB.
PEBR	PEDICULARIS	BRACTEOSA		BENTH.
PEAT 2	PEDICULARIS	ATROSANGUINEA		PENNELL / THOMPS.
PEDAM	PENSTEMON	DAVIDSONII	MENZIESIT	(KECK) CRONQ.
PEME	PENSTEMON	MENZIESII		HOOK.
PEDEV	PENSTEMON	DEUSTUS	VARIABILIS	(SUKSD.) CRONQ.
PEVA	PENSTEMON	VARIABILIS		SUKSD.
PEFRN	PETASITES	FRIGIDUS	NIVALIS	(GREENE) CRONQ.
PENI	PETASITES	NIVALIS		GREENE
PEFRP	PETASITES	FRIGIDUS	PALMATUS	(AIT.) CRONQ.
PEPA	PETASITES	PALMATUS		GRAY
PESP 2	PETASITES	SPECIOSA		NUTT.
PEFRS	PENSTEMON	FRUTICOSUS	SCOULERI	(LINDL.) CRONQ.
PESC	PENSTEMON	SCOULERI		LINDL.
PEGAO	PENSTEMON	GAIRDNERI	OREGANUS	GRAY
PEOR	PENSTEMON	OREGANUS		HOWELL
PELAR	PENSTEMON	LAETUS	ROEZLII	(REGEL) JEPS.
PERO	PENSTEMON	ROEZLII		REGEL
PEPE	PELTIPHYLLUM	PELTATUM		(TORR.) ENGL.
SAPE	SAXIFRAGA	PELTATA		TORR. EX BENTH.
PEPR	PENSTEMON	PROCERUS		DOUGL. EX R. GRAH.
PECA	PENSTEMON	CACUMINIS		PENNELL
PEMI	PENSTEMON	MICRANTHUS		NUTT.
PEPRF	PENSTEMON	PROCERUS	FORMOSUS	(A. NELS.) CRONQ.
PECH	PENSTEMON	CHIONOPHILUS		GREENE

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PEPRT	PENSTEMON	PROCERUS	TOLMIEI	(HOOK.) CRONQ.
PETO	PENSTEMON	TOLMIEI		HOOK.
PERY	PENSTEMON	RYDBERGII		A. NELS.
PEOR 3	PENSTEMON	OREOCHARIS		GREENE
PEWA	PENSTEMON	WASHINGTONENSIS		KECK
PESP	PENSTEMON	SPECIOSUS		DOUGL. EX LINDL.
PEGL 2	PENSTEMON	GLABER		JEPS.
PHCA 2	PHLOX	CAESPITOSA		NUTT.
PHDO	PHLOX	DOUGLASII		HOOK.
PHDOR	PHLOX	DOUGLASII	RIGIDA	PECK
PHDI	PHLOX	DIFFUSA		BENTH.
PHDIL	PHLOX	DIFFUSA	LONGISTYLIS	(WHERRY) PECK
PHHAA	PHACELIA	HASTATA	ALPINA	(RYDB.) CRONQ.
PHAL 2	PHACELIA	ALPINA		RYDB.
PHHAL	PHACELIA	HASTATA	LEUCOPHYLLA	(TORR.) CRONQ.
PHLE	PHACELIA	LEUCOPHYLLA		TORR.
PHHE	PHACELIA	HETEROPHYLLA		PURSH
PHVI	PHACELIA	VIRGATA		GREENE
PHHO	PHLOX	HOODII		RICH.
PHHOC	PHLOX	HOODII	CANESCENS	(T. / G.) PECK
PHLEG	PHILADELPHUS	LEWISII	GORDONIANUS	JEPS.
PHGO	PHILADELPHUS	GORDONIANUS		LINDL.
PHLO	PHLOX	LONGIFOLIA		NUTT.
PHLI 2	PHLOX	LINEARIFOLIA		GRAY
PHLOC	PHLOX	LONGIFOLIA	CALVA	PECK
PHLOH	PHLOX	LONGIFOLIA	HUMILIS	PECK
PHVI 2	PHLOX	VIRIDIS		E. NELS.
PHSP	PHLOX	SPECIOSA		PURSH
PHSPL	PHLOX	SPECIOSA	LANCEOLATA	PECK
PHSPN	PHLOX	SPECIOSA	NITIDA	SUKSD.
PHSPO	PHLOX	SPECIOSA	OCCIDENTALIS	PECK
PLCO	PLECTRITIS	CONGESTA		(LINDL.) DC.
VAAP	VALERIANELLA	APHANOPTERA		GRAY
VACO 2	VALERIANELLA	CONGESTA		LINDL.
PLPA	PLANTAGO	PATAGONICA		JACQ.
PLPU	PLANTAGO	PURSHII		ROEM. / SCHULT.
PLSC 2	PLAGIOBOTHRYS	SCOULERI		(H. / A.) JOHNST.
PLHI	PLAGIOBOTHRYS	HISPIDULUS		JOHNST.
PLSCP	PLAGIOBOTHRYS	SCOULERI	PENICILLATUS	(GREENE) CRONQ.
PLCU	PLAGIOBOTHRYS	CUSICKII		JOHNST.
POAM 2	POLYGONUM	AMPHIBIUM		L.
POBIH	POLYGONUM	BISTORTOIDES	HARTWRIGHTII	GRAY
PONA	POLYGONUM	NATANS		EAT.
POARC	POTENTILLA	ARGUTA	CONVALLARIA	(RYDB.) T. WOLF
POCO 3	POTENTILLA	CORYMBOSA		FEDDE
POCU	POA	CUSICKII		VASEY
POEP	POA	EPILIS		SCRIBN.
PODI	POTENTILLA	DIVERSIFOLIA		LEHM.
POGL 2	POTENTILLA	GLAUCOPHYLLA		LEHM.
PODO	POLYGONUM	DOUGLASII		GREENE
POMO 2	POLYGONUM	MONTANUM		GREENE
PODR	POTENTILLA	DRUMMONDII		LEHM.
POCA 3	POTENTILLA	CASCADENSIS		RYDB.

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POFE	POA	FENDLERIANA		(STEUD.) VASEY
POLO	POA	LONGILIGULA		SCRIBN. / WILLIAMS
POFR 2	POLYCTENIUM	FREMONTII		(WATS.) GREENE
SMFR	SMELOWSKIA	FREMONTII		WATS.
POGL	POTENTILLA	GLANDULOSA		LINDL.
POPU 2	POTENTILLA	PUMILA		FEDDE
PORH	POTENTILLA	RHOMBOIDEA		RYDB.
POVA 2	POTENTILLA	VALIDA		GREENE
POGR	POTENTILLA	GRACILIS		DOUGL. EX HOOK.
POFA	POTENTILLA	FASTIGIATA		HOOK. EX T. / G.
POGR 5	POA	GRAYANA		VASEY
POAR 2	POA	ARCTICA		AUTHORS NOT R. BR.
POGRF	POTENTILLA	GRACILIS	FLABELLIFORMIS	(LEHM.) NUTT. EX T. / G.
POFL	POTENTILLA	FLABELLIFORMIS		LEHM.
POGRG	POTENTILLA	GRACILIS	GLABRATA	(LEHM.) C. L. HITCHC.
POBL	POTENTILLA	BLASCHKEANA		TURCZ. EX LEHM.
POET	POTENTILLA	ETOMENTOSA		RYDB.
POGL 3	POTENTILLA	GLABRATA		LEHM.
POGRN	POTENTILLA	GRACILIS	NUTTALLII	SHELD.
POVI 3	POTENTILLA	VIRIDESCENS		RYDB.
POGRP	POTENTILLA	GRACILIS	PERMOLLIS	(RYDB.) C. L. HITCHC.
POPE 3	POTENTILLA	PERMOLLIS		RYDB.
POGRP2	POTENTILLA	GRACILIS	PULCHERRIMA	(LEHM.) FERN.
POPU 3	POTENTILLA	PULCHERRIMA		LEHM.
POJU	POA	JUNCIFOLIA		SCRIBN.
POAM	POA	AMPLA		MERRILL
POLE 2	POA	LEIBERGII		SCRIBN.
POVA	POA	VASEYOCHLOA		SCRIBN.
POLYG	POLYGONUM			L.
PERSI	PERSICARIA			MEISSN.
PONO	POTENTILLA	NORVEGICA		L.
PONOH	POTENTILLA	NORVEGICA	HIRSUTA	LEHM.
POPA 8	POTENTILLA	PACIFICA		HOWELL
POANG	POTENTILLA	ANSERINA	GRANDIS	T. / G.
POSA 3	POA	SANDBERGII		VASEY
POSE	POA	SECUNDA		AUTHORS NOT PRESL.
POSU	POA	SUKSDORFII		(BEAL) VASEY EX PIPER
POPR 2	POA	PRINGLEI		AUTHORS NOT SCRIBN.
PREM	PRUNUS	EMARGINATA		(DOUGL.) WALPERS
PRPR	PRUNUS	PRUNIFOLIA		SHAFER
PSMEG	PSEUDOTSUGA	MENZIESII	GLAUCA	(BEISSN.) FRANCO
PSTA	PSEUDOTSUGA	TAXIFOLIA		BRITT.
PUNU	PUCCINELLIA	NUTTALLIANA		(SCHULT.) A. S. HITCHC.
PUAI	PUCCINELLIA	AIROIDES		WATS. / COULT.
PUPA	PUCCINELLIA	PAUCIFLORA		(PRESL.) MUNZ
GLPA	GLYCERIA	PAUCIFLORA		PRESL.
PYAS	PYROLA	ASARIFOLIA		MICHX.
PYRO	PYROLA	ROTUNDIFOLIA		L.
PYDE	PYROLA	DENTATA		SMITH
PYPA	PYROLA	PALLIDA		GREENE
PYFU	PYRUS	FUSCA		RAF.
MAFU	MALUS	FUSCA		SCHNEID.

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PYROL	PYROLA			L.
MONES	MONESES			SALISB.
PYUN	PYROLA	UNIFLORA		L.
MOUN	MONESES	UNIFLORA		GRAY
PYVI	PYROLA	VIRENS		SCHWEIGG.
PYCH	PYROLA	CHLORANTHA		SW.
RAFL 2	RANUNCULUS	FLAMMULA		L.
RARE 2	RANUNCULUS	REPTANS		L.
RAFLU	RANUNCULUS	FLAMMULA	UNALASCHENSIS	LEDEB.
RAUN	RANUNCULUS	UNALASCHENSIS		BESS. EX LEDEB.
RAGM	RANUNCULUS	GMELINII		DC.
RAPU	RANUNCULUS	PURSHII		RICHARDS.
RALO 2	RANUNCULUS	LONGIROSTRIS		GODR.
RAAQL	RANUNCULUS	AQUATILIS	LONGIROSTRIS	LAWS.
RANAI	RANUNCULUS	NATANS	INTERTEXTUS	(GREENE) BENSON
RAIN 2	RANUNCULUS	INTERTEXTUS		GREENE
RAUN 2	RANUNCULUS	UNCINATUS		D. DON
RADO	RANUNCULUS	DOUGLASII		HOWELL
RAUNP	RANUNCULUS	UNCINATUS	PARVIFLORUS	(TORR.) L. BENSON
RABO	RANUNCULUS	BONGARDII		GREENE
RHDI	RHUS	DIVERSILOBA		T. / G.
TODI	TOXICODENDRON	DIVERSILOBUM		GREENE
RHQU	RHUS	QUERCIFOLIA		STEUD.
TOQU	TOXICODENDRON	QUERCIFOLIUM		GREENE
RHRA	RHUS	RADICANS		L.
PHRA 3	PHILOSTEMON	RADICANS		RAF.
TOPAR	TOXICODENDRON	RADICANS	RYDBERGII	REHD.
RHUS	RHUS			L.
TOXIC	TOXICODENDRON			L.
RICEC	RIBES	CEREUM	CEREUM	DOUGL.
RIRE	RIBES	RENIFORME		NUTT.
RICR	RIBES	CRUENTUM		GREENE
RIROC	RIBES	ROEZLII	CRUENTUM	REHD.
RIHO	RIBES	HOWELLII		GREENE
RIAC	RIBES	ACERIFOLIUM		HOWELL
RIHUP	RIBES	HUDSONIANUM	PETIOLARE	(DOUGL.) JANCZ.
RIPE	RIBES	PETIOLARE		DOUG..
RIVEG	RIBES	VELUTINUM	GOODDINGII	(PECK) C. L. HITCHC.
RIGO	RIBES	GOODDINGII		PECK
RIWO	RIBES	WOLFII		ROTHROCK
RIMO 2	RIBES	MOGOLLONICUM		GREENE
ROCU	RORIPPA	CURVISILIQUA		(HOOK.) BESSEY EX BRITT.
ROLY	RORIPPA	LYRATA		GREENE
RONUH	ROSA	NUTKANA	HISPIDA	FERN.
ROSP	ROSA	SPALDINGII		CREPIN
ROWOU	ROSA	WOODSII	ULTRAMONTANA	(WATS.) JEPS.
ROPY	ROSA	PYRIFERA		RYDB.
ROUL	ROSA	ULTRAMONTANA		HELLER
RUID	RUBUS	IDAEUS		L.
RUST	RUBUS	STRIGOSUS		MICHX.
RUNI 2	RUBUS	NIGERRIMUS		(GREENE) RYDB.
RUHE	RUBUS	HESPERIUS		PIPER

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RUOCA	RUDBECKIA	OCCIDENTALIS	ALPICOLA	(PIPER) CRONQ.
RUAL	RUDBECKIA	ALPICOLA		PIPER
RUURM	RUBUS	URSINUS	MACROPETALUS	(DOUGL.) BROWN
RUMA	RUBUS	MACROPETALUS		DOUGL.
SAADO	SAXIFRAGA	ADSCENDENS	OREONGENSIS	(RAF.) BREIT.
POOR	PONISTA	OREGONENSIS		RAF.
SAIN 2	SAXIFRAGA	INCOMPTA		PECK
SAAR 5	SALIX	ARCTICA		PALL.
SAPE 2	SALIX	PETROPHILA		RYDB.
SABRA	SAXIFRAGA	BRONCHIALIS	AUSTROMONTANA	(WIEG.) G. N. JONES
SAAU	SAXIFRAGA	AUSTROMONTANA		WIEG.
SACE	SAMBUCUS	CERULEA		RAF.
SAGL	SAMBUCUS	GLAUCA		NUTT. EX T. / G.
SACO 2	SALIX	COMMUTATA		BEBB.
SACOD	SALIX	COMMUTATA	DENUDATA	BEBB.
SACU	SAGITTARIA	CUNEATA		SHELD.
SAAR	SAGITTARIA	ARIFOLIA		NUTT. EX J. G. SM.
SADO	SATUREJA	DOUGLASII		(BENTH.) BRIQ.
MICH	MICROMERIA	CHAMISSONIS		GREENE
MIDO	MICROMERIA	DOUGLASII		BENTH.
SADOC	SALVIA	DORRII	CARNOSA	(DOUGL.) CRONQ.
SACA 2	SALVIA	CARNOSA		DOUGL. EX BENTH.
SADR	SALIX	DRUMMONDIANA		BARRATT
SADRB	SALIX	DRUMMONDIANA	BELLA	BALL
SADRS	SALIX	DRUMMONDIANA	SUBCOERULEA	BALL
SAEX	SALIX	EXIGUA		NUTT.
SAAR 3	SALIX	ARGOPHYLLA		NUTT.
SAME 2	SALIX	MELANOPSIS		NUTT.
SAGR	SANICULA	GRAVEOLENS		POEPP. EX DC.
SASE	SANICULA	SEPTENTRIONALIS		GREENE
SAIN	SAXIFRAGA	INTEGRIFOLIA		HOOK.
SAFR	SAXIFRAGA	FRAGOSA		SUKSD. EX SMALL
SAINC	SAXIFRAGA	INTEGRIFOLIA	COLUMBIANA	(PIPER) C. L. HOOK.
SACO	SAXIFRAGA	COLUMBIANA		PIPER
SAKA	SALSOLA	KALI		L.
SAKAT	SALSOLA	KALI	TENUIFOLIA	TAUSCH
SALAC	SALIX	LASIANDRA	CAUDATA	(NUTT.) SUDW.
SACA 5	SALIX	CAUDATA		HELLER
SAMO 3	SAGITTARIA	MONTEVIDENSIS		CHAM. / SCHLECHT.
LOCA	LOPHOTOCARPUS	CALIFORNICUS		J. G. SM.
SAMY	SALIX	MYRTILLIFOLIA		ANDERSS.
SAPS	SALIX	PSEUDOCORDATA		ANDERSS.
SAOC	SANGUISORBA	OCCIDENTALIS		NUTT.
SAAN	SANGUISORBA	ANNUA		NUTT.
SAOCD	SAXIFRAGA	OCCIDENTALIS	DENTATA	(ENGL. / IRMSCH.) C. L. HITCHC.
SAMAD	SAXIFRAGA	MARSHALLII	DENTATA	ENGL. / IRMSCH.
SAOCR	SAXIFRAGA	OCCIDENTALIS	RUFIDULA	(SMALL) C. L. HITCHC.
SARU	SAXIFRAGA	RUFIDULA		SMALL
SAOF	SANGUISORBA	OFFICINALIS		L.
SAMI	SANGUISORBA	MICROCEPHALA		PRESL.
SAPU	SAXIFRAGA	PUNCTATA		L.
SAAE	SAXIFRAGA	AESTIVALIS		F. / M.

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SAPUC	SAXIFRAGA	PUNCTATA	CASCADENSIS	(CALDER / SAVILE) C. L. HITCHC.
SAPUC2	SAXIFRAGA	PUNCTATA	CASCADENSIS	CALDER / SAVILE
SARAA2	SAMBUCUS	RACEMOSA	ARBORESCENS	(T. / G.) GRAY
SACA	SAMBUCUS	CALLICARPA		GREENE
SARAM	SAMBUCUS	RACEMOSA	MELANOCARPA	(GRAY) MCMINN
SAME	SAMBUCUS	MELANOCARPA		GRAY
SARIM2	SALIX	RIGIDA	MACKENZIEANA	(HOOK.) CRONQ.
SAMA 2	SALIX	MACKENZIANA		BARRATT EX ANDERSS.
SAMO	SALIX	MONOCHROMA		BALL
SARIW	SALIX	RIGIDA	WATSONII	(BEBB.) CRONQ.
SALU	SALIX	LUTEA		NUTT.
SASI 2	SALIX	SITCHENSIS		SANSON
SACO 3	SALIX	COULTERI		ANDERSS.
SATUR	SATUREJA			L.
MICRO	MICROMERIA			BENTH.
SCGA	SCUTELLARIA	GALERICULATA		L.
SCEP	SCUTELLARIA	EPILOBIIFOLIA		HAMILT.
SECA	SENECIO	CANUS		HOOK.
SEHO	SENECIO	HOWELLII		GREENE
SEPU	SENECIO	PURSHIANUS		NUTT.
SECY 2	SENECIO	CYMBALARIOIDES		BUEK
SESU	SENECIO	SUBNUDUS		DC.
SEFOH	SENECIO	FOETIDUS	HYDROPHYLLOIDES	(RYDB.) BARKL.
SEHY 2	SENECIO	HYDROPHILOIDES		RYDB.
SEINE	SENECIO	INTEGERRIMUS	EXALTATUS	(NUTT.) CRONQ.
SECO	SENECIO	COLUMBIANUS		GREENE
SECO 2	SENECIO	CONDENSATUS		GREENE
SEIN 2	SENECIO	INTEGRIFOLIUS		HOOK.
SEINM	SENECIO	INTEGERRIMUS	MAJOR	(GRAY) CRONQ.
SESO	SENECIO	SONNEI		GREENE
SEMU 2	SENECIO	MULTILOBATUS		T. /G.
SEUI	SENECIO	UINTAHENSIS		GREENM.
SENE	SENECIO	NEOWEBSTERI		BLAKE
SEWE	SENECIO	WEBSTERI		GREENM.
SEOR 3	SEDUM	OREGONENSE		(WATS.) PECK
SEWA	SEDUM	WATSONI		TIDESTR.
SEPA	SENECIO	PAUPERCULUS		MICHX.
SETW	SENECIO	TWEEDYI		RYDB.
SEPS	SENECIO	PSEUDAUREUS		RYDB.
SEFL	SENECIO	FLAVULUS		GREENE
SEST 2	SENECIO	STREPTANTHIFOLIUS		GREENE
SECY	SENECIO	CYMBALARIOIDES		NUTT.
SELA	SENECIO	LAETIFLORUS		GREENE
SIDO 2	SILENE	DOUGLASII		HOOK.
SICO	SILENE	COLUMBIANA		HOWELL
SILY	SILENE	LYALLII		WATS.
SIHO	SILENE	HOOKERI		NUTT.
SIIN	SILENE	INGRAMI		TIDESTR. / DAYT.
SIHYB	SITANION	HYSTRIX	BREVIFOLIUM	(J. G. SMITH) C. L. HITCHC.
ELBR	ELYMUS	BREVIFOLIUS		M. E. JONES
SILO 2	SITANION	LONGIFOLIUM		J. G. SMITH
SIHYH	SITANION	HYSTRIX	HORDEOIDES	(SUKSD.) C. L. HITCHC.
SIHO 2	SITANION	HORDEOIDES		(SUKSD.) C. L. HITCHC.

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
SILYB	SILYBUM			ADANS.
MARIA	MARIANA			HILL
SIMA 2	SILYBUM	MARIANA		(L.) GAERTN.
MALA	MARIANA	LACTEA		HILL
SINEC	SIDALCEA	NEOMEXICANA	CRENULATA	(A. NELS.) C. L. HITCHC.
SICR	SIDALCEA	CRENULATA		A. NELS.
SIOR	SIDALCEA	OREGANA		(NUTT.) GRAY
SISP	SIDALCEA	SPICATA		GREENE
SIORE	SIDALCEA	OREGANA	EXIMIA	(GREENE) HITCHC.
SIEX	SIDALCEA	EXIMIA		GREENE
SIPA	SILENE	PARRYII		(WATS.) HITCHC. / MAG.
SIMA	SILENE	MACOUNII		WATS.
SMRA	SMILACINA	RACEMOSA		(L.) DESF.
SMRAA	SMILICINA	RACEMOSA	AMPLEXICAULIS	WATS.
SMST	SMILACINA	STELLATA		(L.) DESF.
SMSE	SMILACINA	SESSILIFOLIA		NUTT.
SMSTS	SMILACINA	STELLATA	SESSILIFOLTA	HENDERS.
SODO	SOLANUM	DOUGLASII		DUNAL
SOUM	SOLANUM	UMBELLIFERUM		ESCHS.
SOMU	SOLIDAGO	MULTIRADIATA		AIT.
SOCI	SOLIDAGO	CILIOSA		GREENE
SOMUS	SOLIDAGO	MULTIRADIATA	SCOPULORUM	GRAY
SOSC	SOLIDAGO	SCOPULORUM		NELS.
SOSA 2	SOLANUM	SARRACHOIDES		SENDT.
SOVI	SOLANUM	VILLOSUM		AUTHORS NOT L.
SOSCC	SORBUS	SCOPULINA	CASCADENSIS	(G. N. JONES) HITCHC.
SOCA 2	SORBUS	CASCADENSIS		G. N. JONES
SOSI	SORBUS	SITCHENSIS		ROEMER
SOSAP	SORBUS	SAMBUCIFOLIA	PUMILA	KOEHNE
SOSIG	SORBUS	SITCHENSIS	GRAYI	(WENZIG) C. L. HITCHC.
SOOC	SORBUS	OCCIDENTALIS		(WATS.) GREENE
SOSP 2	SOLIDAGO	SPATHULATA		DC.
SOGL	SOLIDAGO	GLUTINOSA		NUTT.
SPAS	SPOROBOLUS	ASPER		(MICHX.) KUNTH
AGAS	AGROSTIS	ASPERA		MICHX.
SPBEL	SPIRAEA	BETULIFOLIA	LUCIDA	(DOUGL.) C. L. HITCHC.
SPLU	SPIRAEA	LUCIDA		DOUGL. EX GREENE
SPDOM	SPIRAEA	DOUGLASII	MENZIESII	(HOOK.) PRESL.
SPME	SPIRAEA	MENZIESII		HOOK.
SPDOR	SPIRAEA	DOUGLASII	ROSEATA	(RYDB.) C. L. HITCHC.
SPRO 2	SPIRAEA	ROSEATA		RYDB.
SPIN	SPHENOPHOLIS	INTERMEDIA		(RYDB.) RYDB.
EAIN	EATONIA	INTERMEDIA		RYDB.
SPOB	SPHENOPHOLIS	OBTUSATA		(MICHX.) SCRIBN.
AIOB	AIRA	OBTUSATA		MICHX.
SPPY	SPIRAEA	PYRAMIDATA		GREENE
SPMEP	SPIRAEA	MENZIESII	PYRAMIDATA	PIPER
STCA 2	STELLARIA	CALYCANTHA		(LEDEB.) BONG.
STBO	STELLARIA	BOREALIS		BIGEL.
STCAS	STELLARIA	CALYCANTHA	SITCHANA	(STEUD.) FERN.

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
STAL	STELLARIA	ALPESTRIS		FRIES.
STLO	STELLARIA	LONGIPES		GOLDIE
STLA	STELLARIA	LAETA		RICHARDS.
STME 2	STACHYS	MEXICANA		BENTH.
STCI	STACHYS	CILIATA		DOUGL. EX BENTH.
STOC	STIPA	OCCIDENTALIS		THURB. EX WATS.
STCO	STIPA	COLUMBIANA		MACOUN
STEL	STIPA	ELMERI		PIPER / BRODIE EX SCRIBN.
STWI	STIPA	WILLIAMSII		SCRIBN.
STOCC	STIPA	OCCIDENTALIS	CALIFORNICA	(MERR. / DAVY) C. L. HITCHC.
STCA	STIPA	CALIFORNICA		MERR. / DAVY
STOCN	STIPA	OCCIDENTALIS	NELSONII	(SCRIBN.) C. L. HITCHC.
STCON	STIPA	COLUMBIANA	NELSONI	ST.JOHN
STPA 2	STACHYS	PALUSTRIS		L.
STSC	STACHYS	SCOPULORUM		GREENE
STRI	STACHYS	RIGIDA		NUTT. EX BENTH.
STBU	STACHYS	BULLATA		BENTH.
STSI	STELLARIA	SIMCOEI		(HOWELL) C. L. HITCHC.
ALSI 3	ALSINE	SIMCOEI		HOWELL
STSP 2	STIPA	SPARTEA		TRIN.
STSPC	STIPA	SPARTEA	CURTISETA	A. S. HITCHC.
SURA	SUKSDORFIA	RANUNCULIFOLIA		(HOOK.) ENGL.
SARA 2	SAXIFRAGA	RANUNCULIFOLIA		HOOK.
SWSA	SWAINSONA	SALSULA		(PALL.) TAUB.
PHSA	PHACA	SALSULA		PALL.
SYOR	SYMPHORICARPOS	OREOPHILUS		GRAY
SYRO	SYMPHORICARPOS	ROTUNDIFOLIUS		AUTHORS NOT GRAY
SYVA	SYMPHORICARPOS	VACCINIOIDES		RYDB.
TECA	TETRADYMIA	CANESCENS		DC.
TECAI	TETRADYMIA	CANESCENS	INERMIS	GRAY
TEJA	TELESONIX	JAMESII		(TORR.) RAF.
SAJA	SAXIFRAGA	JAMESII		TORR.
THCU	THYSANOCARPUS	CURVIPES		HOOK.
THEL	THYSANOCARPUS	ELEGANS		F. / M.
THFE	THLASPI	FENDLERI		GRAY
THAL	THLASPI	ALPESTRE		L.
THFEG	THLASPI	FENDLERI	GLAUCUM	(A. NELS.) C. HITCHC.
THGL	THLASPI	GLAUCUM		A. NELS.
THMOO	THERMOPSIS	MONTANA	OVATA	(ROBINS.) ST.JOHN.
THOV	THERMOPSIS	OVATA		RYDB.
THMOV	THERMOPSIS	MONTANA	VENOSA	(EASTW.) JEPS.
THGR	THERMOPSIS	GRACILIS		HOWELL
TOFL 2	TONELLA	FLORIBUNDA		GRAY
COFL	COLLINSIA	FLORIBUNDA		GREENE
TOHO	TOWNSENDIA	HOOKERI		BEAMAN
TOME 2	TOWNSENDIA	MENSANA		JONES
TOLMI	TOLMIEA			T. / G.
LEPTA2	LEPTAXIS			RAF.
TOME	TOLMIEA	MENZIESII		(PURSH) T. / G.
LEME	LEPTAXIS	MENZIESII		RAF.

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
TOTE	TONELLA	TENELLA		(BENTH.) HELLER
COTE 3	COLLINSIA	TENELLA		BENTH.
TRBI	TRIFOLIUM	BIFIDUM		GRAY
TRHA	TRIFOLIUM	HALLII		HOW.
TRERC	TRIFOLIUM	ERIOCEPHALUM	CUSICKII	(PIPER) MARTIN
TRHA 3	TRIFOLIUM	HARNEYENSE		HOW.
TRERE	TRIFOLIUM	ERIOCEPHALUM	ERIOCEPHALUM	NUTT.
TRAR	TRIFOLIUM	ARCUATUM		PIPER
TRLAA	TROLLIUS	LAXUS	ALBIFLORUS	(RYDB.) GRAY
TRAL 2	TROLLIUS	ALBIFLORUS		RYDB.
TRLO	TRIFOLIUM	LONGIPES		NUTT.
TRHA 2	TRIFOLIUM	HANSENI		GREENE
TRLOE	TRIFOLIUM	LONGIPES	ELMERI	E. MODER.
TRMAA	TRIFOLIUM	MACRAEI	ALBOPURPUREUM	(T. / G.) GREENE
TRAL	TRIFOLIUM	ALBOPURPUREUM		T. / G.
TRPR 2	TRIFOLIUM	PROCUMBENS		L.
TRCA 2	TRIFOLIUM	CAMPESTRE		SCHREB.
TRWO 2	TRIFOLIUM	WORMSKJOLDI		LEHM.
TRFI	TRIFOLIUM	FIMBRIATUM		LINDL.
URDIG	URTICA	DIOICA	GRACILIS	(AIT.) SELAND
URGR	URTICA	GRACILIS		AIT.
URDIH	URTICA	DIOICA	HOLOSERICEA	(NUTT.) C. L. HITCHC.
URHO	URTICA	HOLOSERICEA		NUTT.
URDIL	URTICA	DIOICA	LYALLII	(WATS.) C. L. HITCHC.
URBR	URTICA	BREWERI		WATS.
URLY	URTICA	LYALLII		WATS.
VASC 2	VALERIANA	SCOULERI		RYDB.
VASIS	VALERIANA	SITCHENSIS	SCOULERI	PIPER
VASE	VACCARIA	SEGETALIS		(NECK.) GARCKE EX ASCH.
SAVA	SAPONARIA	VACCARIA		L.
VEDU	VENTENATA	DUBIA		COSS. / DUR.
AVDU	AVENA	DUBIA		LEERS
VELA	VERBENA	LASIOSTACHYS		LINK.
VEPR	VERBENA	PROSTRATA		R. BR.
VEVI	VERATRUM	VIRIDE		AIT.
VEES	VERATRUM	ESCHSCHOLTZII		GRAY
VIADA	VIOLA	ADUNCA	ADUNCA	SM.
VIMO	VIOLA	MONTANENSIS		RYDB.
VIRE	VIOLA	RETROSCABRA		GREENE
VIADC	VIOLA	ADUNCA	CASCADENSIS	(M. S. BAKER) C. L. HITCHC.
VICA 4	VIOLA	CASCADENSIS		M. S. BAKER
VIADU	VIOLA	ADUNCA	UNCINULATA	(GREENE) C. L. HITCHC.
VIUN	VIOLA	UNCINULATA		GREENE
VIAMM	VICIA	AMERICANA	MINOR	HOOK.
VISP	VICIA	SPARSIFOLIA		NUTT. EX T. / G.
VITR	VICIA	TRIFIDA		DIETR.
VIAMT	VICIA	AMERICANA	TRUNCATA	(NUTT.) BREW.
VIAMO	VICIA	AMERICANA	OREGANA	NELS.
VIOR	VICIA	OREGANA		NUTT.
VITR 3	VICIA	TRUNCATA		NUTT.
VIAMV	VICIA	AMERICANA	VILLOSA	(KELL.) HERMANN
VICA 2	VICIA	CALIFORNICA		GREENE

SPP. CODE	GENUS NAME	SCIENTIFIC NAME SPECIES EPITHET	VARIETAL EPITHET	SCIENTIFIC NAME AUTHORSHIP
VICAR	VIOLA	CANADENSIS	RUGULOSA	(GREENE) C. L. HITCHC.
VIRU	VIOLA	RUGULOSA		GREENE
VIED	VIBURNUM	EDULE		(MICHX.) RAF.
VIPA	VIBURNUM	PAUCIFLORUM		PYLAIE
VINUR	VIOLA	NUTTALLII	BAKERI	(GREENE) C. L. HITCHC.
VIRA	VIOLA	BAKERI		GREENE
VINUM	VIOLA	NUTTALLI	MAJOR	HOOK.
VIFL	VIOLA	FLAVOVIRENS		POLLARD
VINUP	VIOLA	NUTTALLII	PRAEMORSA	(DOUGL.) WATS.
VIPR	VIOLA	PRAEMORSA		DOUGL. EX LINDL.
XASA	XANTHIUM	SACCHARATUM		WIDDER.
XAAF	XANTHIUM	AFFINE		GREENE
ZIVEG	ZIGADENUS	VENENOSUS	GRAMINEUS	(RYDB.) WALSH.
ZIGR	ZIGADENUS	GRAMINEUS		RYDB.

LIST OF
SOIL SURFACE ITEMS

BAREG	BAREGROUND
BRANC	BRANCHES OR TREE SLASH (OVER 3/4 IN. DIA.) *
CRYPT	CRYPTOGAMS (UNCLASSIFIED) AND MOSSES
GRAVE	GRAVEL OR EROSION PAVEMENT
LITTE	LITTER (RESIDUES, 3/4 IN. DIA. OR LESS) *
LOGS	LOGS
ROCKS	ROCKS (OVER 3/4 IN. DIA.) *
STUMP	STUMPS

* SUGGESTED DEFINITIONS

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

Mailing address: Pacific Northwest Forest and Range
Experiment Station
P.O. Box 3141
Portland, Oregon 97208

The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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1976
USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-47

Forest and Range Soils Research in Oregon and Washington-- A Bibliography With Abstracts From 1969 Through 1974

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PORTLAND, OREGON

ABSTRACT

An annotated bibliography supplementing bibliographies by Tarrant for 1956 through 1963 and by Klock for 1969 through 1974.

Keywords: Soil management (forest), research.

USDA FOREST SERVICE
GENERAL TECHNICAL REPORT PNW-47

FOREST AND RANGE SOILS RESEARCH IN OREGON AND WASHINGTON

a bibliography with abstracts from 1969 through 1974

Compiled by

Glen O. Klock, *Research Soil Scientist*

1976

PACIFIC NORTHWEST FOREST AND RANGE
EXPERIMENT STATION
Forest Service, U.S. Department of Agriculture
Portland, Oregon

PREFACE

This paper cites and briefly summarizes published forest and range soils research in Oregon and Washington for the years 1969 to 1974. It supplements USDA Forest Service Research Papers PNW-15 and PNW-90.[1]

The significant growth of forest and range soils research within Oregon and Washington is quite evident in this paper. Research Paper PNW-15 listed 139 publications from 1914 through 1963, and Research Paper PNW-90 showed 115 publications for the 5-year period 1964-68. This report lists 230 publications from 1969 through 1974. The increased interest in promoting forest and range productivity by fertilization and other soil management techniques and concern for our forest environment appear to be the major reasons for so many soils research publications.

I have attempted to briefly record major findings or the theme of most references. This condensed information is intended only to lead the reader to the original publication.[2] A subject matter index is also included.

I keep an active file of Oregon and Washington forest and range soils research publications and would appreciate being notified of any omissions.

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[1] Robert F. Tarrant (compiler). Forest soils research in Oregon and Washington. A bibliography with abstracts through 1963. USDA Forest Service Research Paper PNW-15, 29 p., 1964. (No longer available from Pacific Northwest Forest and Range Experiment Station.)
Glen O. Klock (compiler). Forest and range soils research in Oregon and Washington, a bibliography with abstracts from 1964 through 1968. USDA Forest Service Research Paper PNW-90, 28 p., 1969.

[2] Publications listed herein are not available from the Pacific Northwest Forest and Range Experiment Station unless issued by the Station.

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1. Abee, Albert, and Denis Lavender.
   1972. Nutrient cycling in throughfall and litterfall in 450-year-old Douglas-fir stands in western Oregon. *In* Jerry F. Franklin et al. (eds.), Proceedings--Research on coniferous forest ecosystems--a symposium, p. 133-143, illus. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

   Comparisons of various major plant nutrients found in canopy throughfall and litterfall were made between six old-growth stands which represented six association types of Douglas-fir.

2. Alban, D. H.
   1969. The influence of western hemlock and western redcedar on soil properties. Soil Sci. Soc. Am. Proc. 33:453-457.

   Many morphological and chemical soil properties were found to differ under individual western hemlock and western redcedar in Washington and Idaho.

3. Anderson, Tom D., and Arthur R. Tiedemann.
   1970. Periodic variation in physical and chemical properties of two central Washington soils. USDA For. Serv. Res. Note PNW-125, 9 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

   Soils derived from two parent materials in central Washington were examined periodically during 1968-69 for physical and chemical properties. Results indicated that periodic variation in certain chemical properties exists and could be a factor in research findings.

4. Aulerich, D. E., K. N. Johnson, and H. Froehlich.
   1974. Tractors or skylines: What's best for thinning young-growth Douglas-fir? For. Ind. (Nov.), 4 p.

5. Baldwin, D. M., N. W. Hawkinson, and E. W. Anderson.
   1974. High-rate fertilization of native rangelands in Oregon. J. Range Manage. 27:214-216.

   Increasing the rate of fertilization up to 1337 kg/ha N on native rangeland improved the vigor of perennial grasses, increased utilization of herbage by cattle, extended the green-forage season, and temporarily increased nitrate nitrogen in the forage.

6. Ballard, T. M.
   1970. Gaseous diffusion evaluation in forest humus. Soil Sci. Soc. Am. Proc. 34:532.

   A steady state CO_2 diffusion method is proposed for measuring the ratio of direct length to effective diffusion path length and gaseous diffusion coefficients in either loose or structurally intact forest humus samples.

7. Ballard, T. M.
   1971. Role of humic carrier substances in DDT movement through forest soil. Soil Sci. Soc. Am. Proc. 35:145-146.

In DDT-treated forest floor columns, over 30 times as much DDT was recovered by leaching with water when urea was added to disperse the humic acids. With similar treatment and analysis, alundum tension lysimeters in soil 2 cm below the forest floor yielded no detectable levels of DDT. In DDT-treated humic extracts, 91 percent of added o,p'-DDT was recovered in humic acids and 9 percent in fulvic acids plus water.

8. Ballard, T. M., and D. W. Cole.
   1974. Transport of nutrients to tree root systems. Can. J. For. Res. 4:563-565.

   Nutrient transport through the soil to roots by mass flow possibly accounts for less than 22, 37, and 80 percent, respectively, of the N, K, and Ca uptake by a Douglas-fir stand growing on a N-deficient soil.

9. Barrett, J. W., and C. T. Youngberg.
   1970. Fertilizing planted ponderosa pine on pumice soils. *In* Regeneration of ponderosa pine, p. 82-88, illus. Oreg. State Univ. Symp. Proc. 1969. Corvallis.

   This paper presents results of four field experiments designed to test the growth response of planted ponderosa pine to seven commercially available fertilizers.

10. Bockheim, J. G., A. K. Schlicte, E. A. Crecelius, and others.
    1969. Compositional variations of the Mazama ash as related to variations in the weathering environment. Northwest Sci. 43:162-173.

11. Bockheim, J. G., and F. C. Ugolini.
    1971. Effect of alpine and subalpine vegetation on soil development, Mt. Baker, Washington. *In* Abstracts of the 44th annual meeting, Northwest Scientific Association, Moscow, Idaho, p. 2.

    Under conditions where parent material, time, topography, and climate are relatively constant, chemical weathering is more advanced in Podzol soils of alpine and subalpine tree clumps than in Alpine Turf soils of adjacent meadows.

12. Bollen, W. B.
    1971. Salty bark as a soil amendment. USDA For. Serv. Res. Pap. PNW-128, 16 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

    Salt content of Douglas-fir bark from logs floated in seawater ranged from 0.75 to 1.94 percent. This salt was readily removed when leached with rainfall or soaked. Salty bark mulches and incorporations depressed growth of bean and tomato plants in the greenhouse. Few soil bacteria were affected by salt.

13. Bollen, W. B., K. C. Lu, and R. F. Tarrant.
    1970. Effect of Zectran on microbial activity in a forest soil. USDA For. Serv. Res. Note PNW-124, 11 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

    When Zectran or No. 2 fuel oil was applied to soil in concentrations far greater than those that could result from current operational application rates, neither material adversely affected soil microbial activity. The authors concluded from these data that low-volume applications of Zectran as an insecticide for forest use poses no hazard to soil microbes.

14. Bollen, W. B., K. C. Lu, J. M. Trappe, and R. F. Tarrant.
1969. Influence of Sitka alder on soil formation and microbiological succession on a landslide of alpine origin at Mount Rainier. USDA For. Serv. Res. Note PNW-103, 5 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

A Sitka alder seedling, growing on 5-year-old avalanche debris below Mount Rainier, led to increased soil carbon and nitrogen and increased microbial populations over a 3-year period.

15. Bollen, W. B., Logan A. Norris, and Kathleen L. Stowers.
1974. Effect of cacodylic acid and MSMA on microbes in forest floor and soil. Weed Sci. 22(6):557-562.

Concentrations of less than 10 mg/kg arsenic in the forest floor had no pronounced effect on organic matter decomposition.

16. Bollen, W. B., and C. M. Tu.
1971. Influence of endrin on soil microbial populations and their activity. USDA For. Serv. Res. Pap. PNW-114, 4 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Endrin applied to soil at rates of more than three times the maximum that might be expected from application of endrin-treated tree seed had no appreciable effect on numbers of soil organisms or on ammonification, nitrification, or sulfur oxidation. Decomposition of soil organic matter was increased significantly in the presence of endrin.

17. Bollen, W. B., and C. M. Tu.
1972. Effects of an organotin on microbial activities in soil. Tin and Its Uses 94:13-15, illus.

TBTO (BIS (tri-N-butyltin) oxide) is a water-insoluble liquid with a high affinity for cellulose. Levels of TBTO to 100 p/m in soil had no biologically significant impact on soil micro-organisms.

18. Bollen, Walter B.
1974. Soil microbes. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. B-1 to B-41, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Desirable soil microbial activity can be enhanced when particle size of residues is reduced, when good contact is provided between residue fragments and soil, and when nitrogen is added or plants are established with nitrogen-fixing nodules.

19. Borchardt, G. A., and M. E. Harward.
1971. Trace element correlation in volcanic ash soils. Soil Sci. Soc. Am. Proc. 35:626-631.

Instrumental neutron activation analysis was used to correlate soils developed on the same volcanic ash deposit.

20. Borchardt, G. A., M. E. Harward, and R. A. Schmitt.
1971. Correlation of volcanic ash deposits by activation analysis of glass separates. Quat. Res. 1:247-260.

21. Boyer, Donald E., and Harold Legard.
1973. Forest land fertilization. 32 p. USDA For. Serv. Pac. Northwest Reg., Portland, Oreg.

22. Brown, George W.
1973. The impact of timber harvest on soil and water resources. Oreg. State Univ. Ext. Bull. 827, 17 p. Corvallis.

23. Brown, George W., Arnold R. Gahler, and Richard B. Marston.
1973. Nutrient losses after clear-cut logging and slash burning in the Oregon Coast Range. Water Resour. Res. 9:1450-1453.

Three small watersheds in Oregon's Coast Ranges were monitored for nutrient release 2 years before and 2 years after logging. No threat to aquatic or terrestrial productivity was observed.

24. Brown, George W., and J. T. Krygier.
1971. Clear-cut logging and sediment production in the Oregon Coast Range. Water Resour. Res. 7:1189-1198.

The impact of road construction, two patterns of clearcut logging, and controlled slash burning on the suspended sediment yield and concentration is reported for three small watersheds in the Oregon Coast Ranges.

25. Burroughs, Edward R., Jr., George R. Chalfant, and Martin A. Townsend.
1973. Guide to reduce road failures in western Oregon. 111 p. Bur. Land Manage., Oreg. State Off., Portland, Oreg.

A training guide designed to provide an introduction to stable road construction on forest lands of western Oregon.

26. Burroughs, Edward R., Jr., and H. A. Froehlich.
1972. Effects of forest fertilization on water quality in two small Oregon watersheds. U.S. Bur. Land Manage., Tech. Note, 8 p. Portland, Oreg.

27. Chichester, F. W., M. E. Harward, and C. T. Youngberg.
1970. pH-dependent ion exchange properties of soils and clays from Mazama pumice. Clays and Clay Miner. 18:81-90.

28. Chichester, F. W., C. T. Youngberg, and M. E. Harward.
1969. Clay mineralogy of soils formed on Mazama pumice. Soil Sci. Soc. Am. Proc. 33:115-120.

Samples of the <2 micrometers fraction in central Oregon had mineral suites consisting predominantly of X-ray amorphous material in combination with a rather complex group of 2:1 phyllosilicates, gibbsite, feldspars, and quartz. The factors primarily controlling clay mineral genesis were hypothesized to be the vesicular structure and chemical composition of the pumiceous parent material.

29. Cline, C. S.
1973. Effects of forest fertilization on the Tahuya River, Kitsap Peninsula, Washington. *In* Abstracts of the 46th annual meeting, Northwest Scientific Association, Walla Walla, Wash., p. 8.

Amounts of urea, ammonia, nitrate, and phosphate entering the river and its tributaries before, during, and after a forest fertilization project in the Tahuya River basin are reported.

30. Cline, C. S., and W. H. Rickard.
1973. Herbage yields in relation to soil water and assimilated nitrogen. J. Range Manage. 26:296-298.

When herbage nitrogen is in the range of 0.5 to 0.7 percent at the end of the spring growing season, nitrogen rather than soil water appears to limit herbage production.

31. Cochran, P. H.
1969. Lodgepole pine clearcut size affects minimum temperatures near the soil surface. USDA For. Serv. Res. Pap. PNW-86, 9 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Narrow widths of cutting strips may be necessary in certain problem areas in pumice soil region of Oregon to obtain natural regeneration of lodgepole pine.

32. Cochran, P. H.
1969. Thermal properties and surface temperatures of seedbeds, a guide for foresters. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., 19 p, illus. Portland, Oreg.

The important thermal properties of soil are defined and discussed together with other influences on temperature variation at the surface.

33. Cochran, P. H.
1971. Pumice particle bridging and nutrient levels affect lodgepole and ponderosa pine seedling development. USDA For. Serv. Res. Note PNW-150, 10 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Root expansion in the C1 horizon of the lapine soil is limited, apparently, because the gravel-size pumice particles bridge together creating a barrier to root penetration. The low nutrient content of the C1 horizon limited the size of the ponderosa pine seedlings but was not the factor restricting depth of root penetration for either lodgepole or ponderosa pine seedlings.

34. Cochran, P. H.
1972. Temperature and soil fertility affect lodgepole and ponderosa pine seedling growth. For. Sci. 18(2):132-134, illus.

Fertilization increased growth of both species under all nine temperature regimes. Lodgepole was not as sensitive to changes in night temperature as was ponderosa pine. The number of daily degree hours required for maximum growth changed with both soil fertility level and night temperature.

35. Cochran, P. H.
1972. Tolerance of lodgepole and ponderosa pine seeds and seedlings to high water tables. Northwest Sci. 46(4):322-331, illus.

Soil water levels close to saturation favored germination of lodgepole over ponderosa pine. When 2-week-old seedlings were subjected to several different soil water levels, both species survived and grew even on saturated soils. Influence of high soil water levels on survival and early growth of the two species is probably not a factor governing "wet-site" occupancy by lodgepole pine on mineral soils.

36. Cochran, P. H.
1973. Natural regeneration of lodgepole pine in south-central Oregon. USDA For. Serv. Res. Note PNW-204, 18 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Several events must occur in sequence for establishment of natural regeneration. These events do not always occur in a reasonable length of time after timber is cut. Leaving a light slash cover on the soil surface favorably modifies the environment, but the practice does not guarantee natural regeneration.

37. Cochran, P. H.
1973. Response of individual ponderosa pine trees to fertilization. USDA For. Serv. Res. Note PNW-206, 15 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Fertilization of one-tenth acre around individual test trees in thinned stands substantially increased growth in three of four areas studied. In the fourth area, top damage probably confounded results.

38. Cole, D. W., S. P. Gessel, and W. J. B. Crane.
1974. Urea reactions and transformation following fertilization to a forest soil. Am. Soc. Agron. Abstr., p. 175.

The chemistry of the soil solution within the top 30 cm shifted markedly after urea was applied to the surface.

39. Cole, Dale W., and Peter S. Machno.
1969. Factors affecting percolation in a forest soil. *In* Proceedings of symposium on water balance in North America, Banff, Alberta, Canada, p. 101-109. Ser. No. 7. Am. Water Resour. Assoc., Urbana, Ill.

40. Dahms, Walter G.
1971. Growth and soil moisture in thinned lodgepole pine. USDA For. Serv. Res. Pap. PNW-127, 32 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

A levels-of-growing-stock study of lodgepole pine showed that individual trees developed longer crowns, grew more rapidly, and added more wood to potentially merchantable trees at lower stand densities, but total wood production was less. Evapotranspiration drain on soil moisture was also less at the lower stand densities.

41. Dahms, Walter G.
1973. Tree growth and water use response to thinning in a 47-year-old lodgepole pine stand. USDA For. Serv. Res. Note PNW-194, 14 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Results from a 5-year levels-of-growing-stock study of lodgepole pine showed soil moisture withdrawal was substantially reduced at lower stand densities.

42. DeBell, D. S., and W. M. Fergerson.
1972. Soils information - an indispensable tool for intensive forest management. Crown Zellerbach Res. Note No. 1, 6 p. Camas, Wash.

Soils information for planning and conducting forestry operations on Crown Zellerbach's northwestern managed forests is reported.

43. DeBell, Dean S.
1973. Effect of application level on gaseous and leaching losses from urea and sulfur-coated urea fertilizers applied to a Douglas-fir soil. *In* Abstracts of the 46th annual meeting, Northwest Scientific Association, Walla Walla, Wash., p. 10.

Under laboratory conditions, ammonia volatility losses averaged 42 percent of total N applied as urea, and only 4 percent for sulfur-coated urea. Leaching losses in the absence of plant uptake varied from 2 to 56 percent of the N application, but differences in total loss were not associated with treatment.

44. DeBell, Dean S.
1973. Gaseous and leaching losses from urea applied to two forest soils as affected by temperature and rainfall. Am. Soc. Agron. Abstr., p. 138.

Gaseous NH_3 losses up to 42 percent were related to soil, temperature, and timing and amount of rainfall. Leaching losses up to 70 percent of NO_3 and NO_2 were related to soil and increased with temperature and amount of rainfall.

45. Dyrness, C. T.
1969. Hydrologic properties of soils on three small watersheds in the western Cascades of Oregon. USDA For. Serv. Res. Note PNW-111, 17 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Soils on three small experimental watersheds were found to permit rapid rates of water movement as a result of their porous nature. The importance of stone content as a hydrologic factor required some revision of the original soil classification scheme before water storage capacity relationships could be correctly assessed.

46. Dyrness, C. T.
1970. Stabilization of newly constructed road backslopes by mulch and grass-legume treatments. USDA For. Serv. Res. Note PNW-123, 5 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Amounts of soil loss from an unprotected newly constructed backslope were two to four times greater than loss from a comparable slope 5 years after construction. Of six roadside treatments studied, the two showing consistently large amounts of soil loss during the first critical rainy period were the ones without a straw mulch covering.

47. Dyrness, C. T.
1972. Soil surface conditions following balloon logging. USDA For. Serv. Res. Note. PNW-182, 7 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Balloon logging caused substantially less soil disturbance than previous studies had shown for tractor, high-lead, and skyline logging methods. Deeply disturbed and compacted soil areas occupied 4.3 percent of the total area, and 15.8 percent of the area was classed as slightly disturbed.

48. Dyrness, C. T.
1973. Early stages of plant succession following logging and burning in the western Cascades of Oregon. Ecology 54:57-69.

Differences in soil disturbance from logging and burning were shown to have a strong influence on successional trends.

49. Edgren, James W., and William I. Stein.
1974. Artificial regeneration. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. M-1 to M-32, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Effects of forest residues on artificial regeneration are discussed.

50. Fowler, W. B.
1974. Microclimate. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. N-1 to N-18, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Examines basic physical processes underlying development of local microclimates and how they are affected by residue generation and treatment.

51. Fowler, W. B., and H. W. Berndt.
1969. Flourescent materials index soil movements. USDA For. Serv. Res. Note PNW-107, 7 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Tracing movement and dispersion of soil-size flourescent particles is a promising method for detecting and describing soil erosion.

52. Fowler, William B.
1971. Measurement of seasonal air temperatures near the soil surfaces. J. Range Manage. 24:158-160, illus.

Large local differences appeared in the onset and duration of temperature extremes as well as absolute seasonal maximum. Plant cover and soil type are major elements accounting for this local variation.

53. Fredriksen, R. L.
1970. Erosion and sedimentation following road construction and timber harvest on unstable soils in three small western Oregon watersheds. USDA For. Serv. Res. Pap. PNW-104, 15 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

In one steep headwater drainage with road construction and patch-cut logging, total stream-carried sediment over a 9-year period was more than 100 times greater than that from an undisturbed watershed. Ninety-nine percent originated from landslides. In a clearcut-logged watershed with no roads, sedimentation was three times greater than that from an undisturbed watershed.

54. Fredriksen, R. L.
1971. Comparative chemical water quality--natural and disturbed streams following logging and slash burning. *In* Forest land uses and stream environment symposium proceedings, 1970, p. 125-137, illus. Oreg. State Univ., Corvallis.

Following timber harvest on a watershed, loss of nutrients increased 1.6 to 3.0 times. Details of chemicals and rate of loss are given.

55. Fredriksen, R. L.
1972. Impact of forest management on stream water quality in western Oregon. *In* Pollution abatement and control in the forest products industry, 1971-72, Proceedings, 26th annual meeting, p. 37-50, illus. For. Prod. Res. Soc.

Sedimentation of streams in Douglas-fir forests is often serious where roads for timber removal cross steep topography. The rise in nutrient concentration after clearcutting and burning and after fertilization declines rapidly as vegetation regrows. Rise in stream temperature can be minimized if shade for stream is left after logging.

56. Fredriksen, R. L.
1972. Nutrient budget of a Douglas-fir forest on an experimental watershed in western Oregon. *In* Jerry F. Franklin et al. (eds.), Proceedings--Research on coniferous forest ecosystems--a symposium, p. 115-131, illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

The study involved nitrogen, phosphorus, the cations, and silica amounts added by precipitation and retained by the forest as well as hypotheses about processes regulating their loss from the forest.

57. Fritschen, L. J., L. W. Gay, and H. R. Holbo.
1974. Estimating evapotranspiration from forests by meteorological and lysimetric methods. *In* R. H. Waring and R. L. Edmonds (eds.), Integrated research in the Coniferous Forest Biome. Coniferous For. Biome Bull. No. 5 (1972):35-40. Univ. Wash., Seattle.

58. Fritschen, Leo J.
1972. The lysimeter installation on the Cedar River watershed. *In* Jerry F. Franklin et al. (eds.), Proceedings--Research on coniferous forest ecosystems--a symposium, p. 255-260, illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

A lysimeter container was built around a 28-m Douglas-fir tree to provide information on rates of evapotranspiration and interception for short periods.

59. Fritschen, Leo J., Lloyd Cox, and Russel Kinerson.
1973. A 28-meter Douglas-fir tree in a weighing lysimeter. For. Sci. 19:256-261.

A 3.7-m diameter by 1.2-m deep soil container was constructed around the root ball of a 28-m Douglas-fir in a naturally regenerated stand.

60. Froehlich, Henry.
1974. Soil compaction: Implication for young-growth management. *In* A. B. Berg (ed.), Managing young forests in the Douglas-fir region, p. 49-64. Sch. For. Symp., Oreg. State Univ., Corvallis.

Describes the importance of soil density for growth of seedlings and young stands, the impact of harvesting on soil density, and the implication for forest productivity.

61. Froehlich, Henry A.
1973. The impact of even age forest management on physical properties of soils. *In* R. K. Hermann and D. P. Lavender (eds.), Even-age management, p. 199-220. Symp. Proc., Oreg. State Univ., Corvallis.

62. Geist, J. Michael.
1973. Physical and chemical properties of volcanic ash and basalt-derived forest soils of northeastern Oregon. Am. Soc. Agron. Abstr., p. 138-139.

Ash materials at low moisture tension showed yields of soil water which was lost rapidly with increasing tension. Basalt soils held less water and released it at a slower rate with increasing tension. Contrast between bulk densities, exchangeable bases, organic matter, and available phosphorus are given.

63. Geist, J. Michael.
1973. Total soil nitrogen analysis using micro-Kjeldahl digestion and portable distillation equipment. USDA For. Serv. Res. Note PNW-198, 8 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Equipment modifications and methodology alternatives for determining total nitrogen in soils with a micro-Kjeldahl digestion apparatus were investigated. Results showed that an air shield over the flask bulbs and a standard copper catalyst-salt mixture should give satisfactory recovery in routine analyses with a running time and sample size similar to those used with macro-Kjeldahl racks. Recovery of several standards was high (96-99 percent), but for recovery of highly refractory compounds, adjustments in methodology will be required.

64. Geist, J. Michael.
1974. Chemical characteristics of some forest and grassland soils of northeastern Oregon. II. Progress in defining variability in Tolo and Klicker soils. USDA For. Serv. Res. Note PNW-217, 15 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Contrasts in general and specific nutrient statuses, trends by soil depth increment, and management implications are discussed. Data are stratified by soil series and by overstory dominant vegetation.

65. Geist, J. Michael, Paul J. Edgerton, and Gerald S. Strickler.
1974. 'Yukky to yummy'--with fertilizers. Rangeman's J. 1(2):39-41, illus.

An experiment was conducted to determine effects of fertilizer on growth and protein content of timothy seeded in a clearcut but, instead, the fertilizer attracted elk.

66. Geist, Jon M.
1971. Orchardgrass responses to fertilization of seven surface soils from the Central Blue Mountains of Oregon. USDA For. Serv. Res. Pap. PNW-122, 12 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

"Orchardgrass responses to N, P, and S applied singly and in combination differed among seven soils studied. Dry matter production showed a significant interaction between N and S treatments in all instances. Only two soils showed a significant response to phosphorus. Largest overall treatment responses were noted on Klicker and volcanic-ash-derived soils."

67. Geist, Jon M., and Gerald S. Strickler.
1970. Chemical characteristics of some forest and grassland soils of northeastern Oregon. I. Results from reference profile sampling on the Starkey Experimental Forest and Range. USDA For. Serv. Res. Note PNW-137, 11 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Chemical soil properties are quantified for individual profiles of six soil series on the Starkey Experimental Forest and Range. Comparisons are made among the study results and with data reported in the literature for some similar soils. Major differences noted include C/N ratios and available phosphorus.

68. Gessel, S. P.
1969. Increasing yield through soil management. Proc., 60th West. For. and Conserv. Assoc. Conf., Spokane, Wash., p. 52-55.

69. Gessel, S. P.
1969. Introduction for forest fertilization in North America. For. Ind., August, p. 1-3.

70. Gessel, S. P.
1969. Status of forest fertilization in the Northwest. *In* Proceedings of the 20th annual Pacific Northwest fertilizer conference, Spokane, Wash., p. 19-36.

71. Gessel, S. P., D. W. Cole, and E. C. Steinbrenner.
1972. Nitrogen balances in forest ecosystems of the Pacific Northwest. Soil Biol. and Biochem. 5:19-34.

72. Gessel, S. P., D. W. Cole, and J. Turner.
1973. Elemental cycling and even-age forest management. *In* R. K. Hermann and D. P. Lavender (eds.), Even-age management, p. 179-198. Symp. Proc., Oreg. State Univ., Corvallis.

73. Gessel, S. P., W. Crane, and D. W. Cole.
1972. Environmental aspects of nitrogenous fertilization in forests. Aust. For. Tree Nutr. Conf., p. 210-219. Sydney, Aust.

74. Gessel, S. P., and N. W. Foster.
1972. The natural addition of nitrogen, potassium, and calcium to a *Pinus banksiana* Lamb. forest floor. Can. J. For. Res. 2:448-455.

75. Gessel, S. P., T. N. Stoate, and J. K. Turnbull.
1969. The growth behavior of Douglas-fir with nitrogenous fertilizer in western Washington. Inst. For. Prod., Univ. Wash., Contrib. 7 p. Seattle.

76. Gessel, S. P., R. B. Walker, T. N. Stoate, and I. G. Morison.
1972. Research on nitrogen and additional elements in the Douglas-fir region. Aust. For. Tree Nutr. Conf., p. 183-190. Sydney, Aust.

77. Gilmour, C. M., C. T. Youngberg, R. L. Pratt, and S. M. Beck.
1973. Energy flow as determined by rates of coniferous forest litter decomposition. Am. Soc. Agron. Abstr., p. 91.

Studies indicate that the overall forest litter decomposition process could be expressed in terms of first-order-kinetics and a half-life substrate decay equation.

78. Grier, C. C.
1972. Impact of forest fire on components of mineral cycling processes in a ponderosa pine ecosystem. *In* Abstracts of 45th annual meeting, Northwest Scientific Association, p. 6. West. Wash. State Coll., Bellingham.

79. Grier, C. C.
1973. Organic matter and nitrogen distribution in some mountain heath communities of the Source Lake Basin, Washington. Arctic and Alpine Res. 5, Part 1:261-267.

The soils and vegetation of subalpine mountain heath communities on colluvial residual and organic soils in the Source Lake Basin of the west-central Cascade Range, Washington, were described and sampled for organic matter and nitrogen content in foliage, living stems, attached dead stems, roots, litter, and soil.

80. Grier, C. C., D. W. Cole, C. T. Dyrness, and R. L. Fredriksen.
1974. Nutrient cycling in 37- and 450-year-old Douglas-fir ecosystems. *In* R. H. Waring and R. L. Edmonds (eds.), Integrated research in the Coniferous Forest Biome. Coniferous For. Biome Bull. No. 5 (1972):21-34. Univ. Wash., Seattle.

81. Grier, C. C., and J. G. McColl.
1971. Forest floor characteristics within a small plot in Douglas-fir in western Washington. Soil Sci. Soc. Am. Proc. 35:988-991.

Selected chemical and physical properties and their variabilities within a 0.04-ha plot were determined.

82. Grier, Charles C., and Dale W. Cole.
1971. Influence of slash burning on ion transport in a forest soil. Northwest Sci. 45:100-106.

Slash burning was shown to substantially increase the concentration of ions entering the soil.

83. Grier, Charles C., and Dale W. Cole.
1972. Elemental transport changes occurring during development of a second-growth Douglas-fir ecosystem. *In* Jerry F. Franklin et al. (eds.), Proceedings--Research on coniferous forest ecosystems--a symposium, p. 103-114, illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Six years of intensive monitoring on the H. H. Thompson Research Center provides information on the transfer rates of elements between components of of a second-growth Douglas-fir ecosystem.

84. Harr, R. D.
1973. Field transport of the neutron soil-moisture meter in steep terrain. J. Soil and Water Conserv. 28:181-182.

85. Harwood, M. E., and C. T. Youngberg.
1969. Soils from Mazama ash in Oregon: Identification, distribution, and properties. *In* Proceedings, Pedology and quaternary research, Symposium, May 13-14, 1969, p. 163-178. Univ. Alberta, Edmonton.

86. Hatheway, W. H., P. Machno, and E. Hamerly.
1972. Modeling water movement within the upper rooting zone of a Cedar River soil. *In* Jerry F. Franklin et al. (eds.), Proceedings--Research on coniferous forest ecosystems--a symposium, p. 95-101. USDA For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Observations on the advance of wetting fronts have been obtained by lysimeter techniques and have been analyzed with moisture flow equations for a porous soil.

87. Hawk, G. M., and D. B. Zobel.
1974. Forest successions on alluvial landforms of the McKenzie River Valley, Oregon. Northwest Sci. 48:245-265.

A major factor leading to vegetation succession differences appears to be soil moisture availability in late summer.

88. Heilman, P.
1974. Effect of urea fertilization on nitrification in forest soils of the Pacific Northwest. Soil Sci. Soc. Am. Proc. 38:664-667.

Levels of nitrate in samples of untreated, incubated soils from Douglas-fir (*Pseudotsuga menziesii*) and western hemlock (*Tsuga heterophylla*) stands varied from 0 to 45 p/m nitrate N. Treatment with urea increased nitrate N in incubated samples an average of 70 p/m, but the increase varied widely among soils. Earlier N fertilization increased nitrification of urea. Nitrification was restricted at temperatures below 5^{0} C.

89. Heilman, P., and G. Ekuan.
1973. Response of Douglas-fir and western hemlock seedlings to lime. For. Sci. 19:220-224.

High rates of lime produced a significant reduction in western hemlock (*Tsuga heterophylla* (Raf.) Sarg.) growth on low-base forest soils used in pot experiments. Application of P alone, or in combination with lime, had no significant effect on the growth of seedlings. The N, Ca, and Mg contents of Douglas-fir leaves were increased by lime, but those of Mn and Al were decreased. In western hemlock the effects were similar, except that K and Mg were reduced. Lime increased soil pH, exchangeable Ca content, and base saturation of the soil. Extractable K, Mg, and P were slightly decreased in soil treated with high rates of lime.

90. Helvey, J. D.
1974. Soil moisture depletion and growth rates after thinning ponderosa pine. *In* Abstracts of 47th annual meeting, Northwest Scientific Association, Vancouver, B.C., p. 15.

Depletion from heavily thinned plots near Baker, Oregon, averaged 8.6 cm less than from control plots the first three summers after treatment. Increases in growth rate during the first 5 years after thinning were largest in stands thinned to 4.6-m spacing.

91. Herman, R. K., and R. G. Petersen.
1969. Root development and height increment of ponderosa pine in pumice soils of central Oregon. For. Sci. 15:226-237.

Trees were excavated from three different pumice soils in central Oregon and inspected for root growth characteristics.

92. Herring, H. G.
1970. Soil moisture trends under three different cover conditions. USDA For. Serv. Res. Note PNW-114, 8 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

A study of soil moisture trends under a grassy opening, a second-growth ponderosa pine stand, and a clearcut plot indicates that if a pine stand were converted to grass as a water-saving scheme, the ultimate benefits might be only 20 percent as great as the initial savings after clearcutting.

93. Hu, L., C. T. Youngberg, and C. M. Gilmour.
1972. Readily oxidizable carbon: An index of decomposition and humification of forest litter. Soil Sci. Soc. Am. Proc. 36:959-961.

Carbon dioxide evolution rates are higher from organic horizons undergoing active decomposition (F-layers) than from well-decomposed and humified horizons (H-layers) and are relatively good indexes of decomposition and humification. Water-soluble carbon contents correlate well with CO_2 evolution values. The more rapid soluble carbon analysis makes this the preferred method for determining stage of decomposition and humification.

94. Johnson, D. W., M. J. Singer, and R. Minden.
1974. Nutrient cycling in a subalpine *Abies* forest. II. Processes of mineral transfer. *In* Abstracts of 47th annual meeting, Northwest Scientific Association, Vancouver, B.C., p. 36.

The carbonic acid mechanism was found to play a major role in cation leaching in lower elevation *Pseudotsuga menziesii* stands, but it plays a much smaller role in high elevation *Abies amabilis* stands because of the greater acidity of soil solutions.

95. Klock, G. O.
1969. Some autecological characteristics of elk sedge. USDA For. Serv. Res. Note PNW-106, 5 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

"Cores" of elk sedge were successfully transplanted to the laboratory to investigate this method of reproduction and to provide material for tests of this plant's response to fertilization. Elk sedge showed positive response to nitrogen and potassium fertilization.

96. Klock, G. O.
1969. Use of a starter fertilizer for vegetation establishment. (Abstr.) Northwest Sci. 43:38.

Use of a nitrogen-sulfur fertilizer at planting time appeared imperative for satisfactory establishment of vegetation on disturbed forest soils of low fertility in north-central Washington.

97. Klock, G. O.
1971. Forest erosion control fertilization and streamflow nitrogen loss. West. Soc. Soil Sci. Abstr., p. 12.

98. Klock, G. O.
1971. Streamflow nitrogen loss following forest erosion control fertilization. USDA For. Serv. Res. Note PNW-169, 9 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Reports estimated quantities of urea-N, nitrate-N, and ammonia-N loss through streamflow for 60 days following fertilization of watersheds on the Entiat Experimental Forest severely affected by wildfire.

99. Klock, G. O.
1972. Soil moisture trends on mountain watersheds following forest fire. *In* Abstracts of 45th annual meeting, Northwest Scientific Association, Bellingham, Wash., p. 7.

Compares soil moisture before and after wildfire on the Entiat Experimental Forest in north-central Washington.

100. Klock, G. O.
1973. Helicopter logging reduces soil surface disturbance. *In* Abstracts of the 46th annual meeting, Northwest Scientific Association, Walla Walla, Wash., p. 20.

Helicopter fire salvage logging was shown to cause strikingly less severe surface soil disturbance than high lead-jammer cable skidding or tractor logging methods.

101. Klock, G. O.
1973. Selection of timber harvesting method may be based on soil erosion potential. Am. Soc. Agron. Abstr., p. 140.

Models from this study demonstrate that an opportunity exists on western timberlands for use of soil erosion potential as an important parameter in selecting the most appropriate harvesting technique.

102. Klock, G. O., and L. L. Boersma.
1971. Hard to drain soil responds to plastic tubing. Crops and Soils (January), p. 23-24.

Perforated plastic drainage pipes offer promise of reducing the cost per foot of drain.

103. Klock, G. O., and J. M. Geist.
1971. Sulfur-coated urea and its possible use in erosion control fertilization. *In* Abstracts of the 42nd annual meeting, Northwest Scientific Association, Moscow, Idaho, p. 7.

The availability of sulfur along with the urea-nitrogen in SCU appears to be beneficial for plant growth in erosion control seedings.

104. Klock, G. O., J. M. Geist, and A. R. Tiedemann.
1971. Erosion control fertilization--from pot study to field testing. Sulphur Inst. J. 7(3):7-10, illus.

Field experimentation was initiated in conjunction with the greenhouse study to evaluate nitrogen and sulfur relations in the natural environment. Seeding along with a starter fertilizer was recommended for some locations. In some areas, sulfur as well as nitrogen was recommended.

105. Klock, G. O., and W. Lopushinsky.
1970. Use of thermocouple psychrometers to measure soil water potential in the root zone of conifer seedlings. *In* Abstracts of the 43rd annual meeting, Northwest Scientific Association, Salem, Oreg., p. 64.

Thermocouple psychrometers proved to be a quick, accurate method of measuring soil water potential in many potted conifers.

106. Klock, G. O., A. R. Tiedemann, and W. Lopushinsky.
1974. Seeding trials on firelines in north central Washington. *In* Abstracts of 47th annual meeting, Northwest Scientific Association, Vancouver, B.C., p. 16.

Fertilization was essential for the establishment of introduced species on firelines where the soils were severely disturbed.

107. Klock, Glen.
1973. Mission Ridge - a case history of soil disturbance and revegetation of a winter sports area development. USDA For. Serv. Res. Note PNW-199, 10 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Areas of soil disturbance caused by construction of a winter sports area are identified, and the private operator's use of forest research findings to reduce the effect of these disturbances are reviewed.

108. Klock, Glen O.
1969. A "vacuum-freeze" technique to prepare disturbed soil for erosion research. West. Soc. Soil Sci. Abstr., p. 19.

A vacuum-freeze technique was developed to establish some structure in soil samples brought from the field for laboratory erosion susceptibility testing.

109. Klock, Glen O.
1969. Forest and range soils research in Oregon and Washington, a bibliography with abstracts from 1964 through 1968. USDA For. Serv. Res. Pap. PNW-90, 28 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

An annotated bibliography continuing a series of bibliographies previously published by Pacific Northwest Forest and Range Experiment Station.

110. Klock, Glen O.
1972. Snowmelt temperature influence on infiltration and soil water retention. J. Soil and Water Conserv. 27:12-14, illus.

Effect of snowmelt water on infiltration and soil water retention is shown by theory and experimentation. Watershed management implications, including possible overland flow hazards and effects of thinning, clearcutting, and wildfire, are discussed.

111. Klock, Glen O.
1974. Site factors influencing erosion on forest and range soils developed from Swauk sandstones. West. Soc. Soil Sci. Abstr., p. 7-8.

Infiltration, slope, and vegetative cover were identified as the most important site factors influencing erosion.

112. Klock, Glen O., and Walter A. Hampton.
1972. Skiiing--'and on grass base.' Wash. Farmer-Stockman 97(2):34, illus.

The successful planting procedures developed here could be adapted to revegetation of ski slopes and other disturbed areas in many places along the upper slopes of the Cascade Range.

113. Kruckeberg, A. R.
1969. Plant life on serpentine and other ferromagnesian rock in northwestern North America. Syesis 2:15-114.

In Oregon, Washington, and British Columbia, vegetation on ferromagnesian rocks such as serpentinite, peridotite, and dunite often contrasts markedly with that on adjacent but different rock types.

114. Li, C. Y., K. C. Lu, J. M. Trappe, and W. B. Bollen.
1970. Separation of phenolic compounds in alkali hydrolysates of a forest soil by thin-layer chromatography. Can. J. Soil Sci. 50:458-460.

115. Li, C. Y., K. C. Lu, J. M. Trappe, and W. B. Bollen.
1972. Nitrate-reducing capacity of roots and nodules of *Alnus rubra* and roots of *Pseudotsuga menziesii*. Plant and Soil 37(2):409-414.

Alder roots and nodules reduce nitrate nitrogen to the nitrate form, whereas Douglas-fir roots do not. Since a nitrate reduction capacity is required for absorption of nitrate nitrogen from soil, the good response of Douglas-fir to fertilization with nitrate nitrogen is probably via nitrate-reducing, fungi-forming mycorrhizae with its roots.

116. Lopushinsky, W., and G. O. Klock.
1974. Transpiration of conifer seedlings in relation to soil water potential. For. Sci. 20(2):181-186, illus.

In response to decreasing soil water potential, the transpiration rates of *Pinus ponderosa* and *Pinus contorta* seedlings declined to a greater degree than the transpiration of *Pseudotsuga menziesii* and *Abies grandis* seedlings. The response of *Picea engelmannii* was intermediate between the pines and the firs.

117. Lowery, R.
1972. Effect of soil temperature and moisture content on early root development in three high elevation tree species. *In* Abstracts of the 45th annual meeting, Northwest Scientific Association, Bellingham, Wash., p. 8.

Root development for mountain hemlock, alpine fir, and Pacific silver fir was found to be a function of soil temperature and soil moisture content.

118. Lu, K. C.
1974. Phenolic compounds and *Poria weirii*. Proc., Eighteenth West. Int. For. Dis. Work Conf., Harrison Hot Springs, B.C., Can., Sep. 14-18, 1970, p. 45-48.

Red alder roots, resistant to the root-rotting fungus *Poria weirii*, contain several *Poria*-inhibiting compounds. Some of these occur in soil under alder. Roots of the highly susceptible Douglas-fir contain a *Poria*-stimulating compound.

119. McCall, M.
1970. The effects of aerial forest fertilization on water quality for two streams in the Capitol Forest. Wash. State Dep. Ecol., 20 p. Olympia.

120. McColl, J. G.
1972. Dynamics of ion transport during moisture flow from a Douglas-fir forest floor. Soil Sci. Soc. Am. Proc. 36:668-674.

Ion transport from the forest floor was found to be related to temperature regime, duration of time before flow, and amount of moisture flow.

121. McColley, P. D., and H. S. Hodgkinson.
1970. Effect of soil depth on plant production. J. Range Manage. 23:189-192.

Three range soils in eastern Washington with different depths produced different kinds and amounts of forage.

122. McConnell, Burt R., and Justin G. Smith.
1971. Effect of ponderosa pine needle litter on grass seedling survival. USDA For. Serv. Res. Note PNW-155, 6 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Hard fescue survival rates were followed for 6 years on four different pine needle treatment plots. Needle litter had a significant effect on initial survival of fescue seedlings, but subsequent losses undoubtedly resulted from interaction of many factors.

123. Mallonee, E. H., R. F. Strand, D. S. DeBell, and J. Y. Zin.
1974. Effects of fertilization on growth of young Douglas-fir plantations near Campbell River, British Columbia. Crown Zellerbach For. Res. Note 3, 7 p. Camas, Wash.

124. Malueg, K. W., and D. F. Krawczyk.
1972. Effects of aerial forest fertilization with urea pellets on nitrogen levels in a mountain stream. Northwest Sci. 46:52-58.

The effects on water quality from fertilization of 569 acres of 35-year-old Douglas-fir forest in Linn County, Oregon, are reported.

125. Manhart, L. G., and E. P. Harshman.
1971. Pumice soil-vegetation relationships of Oregon's central high Cascades. Am. Soc. Agron. Abstr., p. 120.

Depth or thickness of the soil beneath the pumice is a key indicator of areas suitable for management for protection of soil, water, and wildlife resources.

126. Mersereau, R. C., and C. T. Dyrness.
1972. Accelerated mass wasting after logging and slash burning. J. Soil and Water Conserv. 27(3):112-114, illus.

Clearcut logging and slash burning in a steep watershed in western Oregon resulted in increased rates of soil movement during the first year after burning. Measured soil and rock movement occurred mainly during the dry season, and amounts were closely tied to steepness of slope, aspect, vegetative cover, and length of time since burning.

127. Meurisse, R. T., and C. T. Youngberg.
1972. Biological assay of four andic soils from the western Oregon fog-belt zone. Am. Soc. Agron. Abstr., p. 141.

Monterey pine seedlings were grown for 6 months in the greenhouse on four soils from western hemlock sites to test response to fertilizer.

128. Miller, R. E., and L. V. Pienaar.
1973. Seven-year response of 35-year-old Douglas-fir to nitrogen fertilizer. USDA For. Serv. Res. Pap. PNW-165, 24 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Applying ammonium nitrate fertilizer to a site V plantation resulted in significant increases in tree diameter, height growth, and in volume growth during the 7 years after treatment.

129. Miller, R. E., and D. C. Young.
1974. Comparative effects of foliar- and soil-applied nitrogen fertilizers on Douglas fir: II. Tree growth. Am. Soc. Agron. Abstr., p. 177.

Experimental results suggest that concentrated urea-ammonium nitrate solution sprays can provide similar growth response in Douglas-fir and western hemlock as urea prill at N-dosages up to 179 to 224 kg/ha.

130. Miller, Richard E., and Richard L. Williamson.
1974. Dominant Douglas-fir respond to fertilizing and thinning in southwest Oregon. USDA For. Serv. Res. Note PNW-216, 7 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

In 30-year-old, site IV Douglas-fir in southwest Oregon, fertilizing increased average 4-year basal area growth of dominant trees by 57 and 28 percent on clay loam and sandy loam soils, respectively. Fertilizing with thinning increased growth by 94 and 132 percent over untreated growth. Thinning on clay loam soil increased growth by 53 percent. Treatment did not affect height growth on either soil.

131. Miller, Richard E., Richard L. Williamson, and Roy R. Silen.
1974. Regeneration and growth of coastal Douglas-fir. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. J-1 to J-41. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Environmental requirements for regenerating coastal Douglas-fir are described.

132. Minore, Don.
1971. Effects of flooding and shallow water tables on survival and growth of six northwestern tree species. *In* Abstracts of the 44th annual meeting, Northwest Scientific Association, Moscow, Idaho, p. 9.

Redcedar and lodgepole pine seedlings best tolerated flooding. Redcedar and alder best tolerated shallow water tables. Douglas-fir seedlings tolerated neither flooding nor shallow water tables.

133. Minore, Don.
1972. A classification of forest environments in the South Umpqua Basin. USDA For. Serv. Res. Pap. PNW-129, 28 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

A classification of forest environments by elevation, temperature, moisture, potential solar radiation, and soil type is described. It facilitates comparisons of forested areas--comparisons that eventually should make it possible to prescribe optimal management practices for every forest environment in the South Umpqua Basin.

134. Minore, Don, Clark E. Smith, and Robert F. Woollard.
1969. Effects of high soil density on seedling root growth of seven northwestern tree species. USDA For. Serv. Res. Note PNW-112, 6 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Lodgepole pine, Douglas-fir, and red alder roots appear to grow in soil densities that prohibit the growth of Sitka spruce, western hemlock, and western redcedar roots. Pacific silver fir appears intermediate.

135. Mitchell, R. G., and H. G. Paul.
1974. Field fertilization of Douglas-fir and its effect on *Adelges cooleyi* populations. Environ. Entomol. 3:501-504, illus.

Population levels of *Adelges cooleyi* (Gillette) were estimated on 7-year-old Douglas-fir trees after fertilization with three forms of nitrogen--ammonium nitrate and urea solutions and urea prill. In the first year, egg production on trees individually treated with equivalents of 50 and 200 lb N/acre was 11-42 percent higher than on untreated trees. Winter survival of the aphid was also higher than normal on fertilized trees. However, low rates of establishment on fertilized trees negated these increases. Two years after fertilization, the populations were essentially the same on treated and untreated trees.

136. Mohan, J. M.
1973. 14 years of rabbitbrush control in central Oregon. J. Range Manage. 26:448-451.

Effective kill of rabbitbrush with herbicides depends on the amount of new twig growth, soil moisture, rate and methods of application, total seasonal twig growth, and subsequent drought conditions.

137. Moore, D. G.
1972. Effects of forest fertilization with urea on stream water quality. Am. Soc. Agron. Abstr., p. 141.

Aerial fertilization of a 68.39-ha forested watershed with urea at 224 kg N/ha resulted in a streamflow loss of 0.38 kg N/ha during the first year after application.

138. Moore, Duane G.
1970. DDT in forest soils of western Oregon. *In* Abstracts of the 43rd annual meeting, Northwest Scientific Association, Salem, Oreg., p. 65-66.

DDT residue was found in all samples of forest floor and mineral soil collected along four east-west transects across the Coast and Cascade Ranges of Oregon even though only one site received a direct application of insecticide.

139. Moore, Duane G.
1971. Fertilization and water quality. *In* Western reforestation, p. 28-31. West. Refor. Coord. Comm. Proc., 1971. West. For. and Conserv. Assoc., Portland, Oreg.

Time, form, and amount of nitrogen lost from a 169-acre watershed in the South Umpqua Experimental Forest are described for the first year after fertilization.

140. Moore, Duane G., and Logan A. Norris.
1974. Soil processes and introduced chemicals. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. C-1 to C-33, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

141. Morris, William G.
1970. Effects of slash burning in overmature stands of the Douglas-fir region. For. Sci. 16:258-270.

Pairs of burned and unburned plots were used to determine the effects of fall slash burning in clearcuts of old-growth coniferous forests in western Oregon and Washington.

142. Moshev, M. M.
1971. Irrigation and fertilization of ponderosa pine. *In* Abstracts of the 44th annual meeting, Northwest Scientific Association, Moscow, Idaho, p. 9.

A 10-year study showed that irrigation and fertilization of ponderosa pine increased diameter growth and cone production.

143. Nelson, Earl E.
1969. Occurrence of fungi antagonistic to *Poria weirii* in a Douglas-fir forest soil in western Oregon. For. Sci. 15:49-54, illus.

Five fungi isolated from soil by the dilution plate technique, about 6.7 percent of total fungi counted, were antagonistic to *Poria weirii* on malt agar. Total fungus counts fluctuated seasonally, depending chiefly on soil moisture content.

144. Nelson, Earl E.
1970. Effects of nitrogen fertilizer on survival of *Poria weirii* and populations of soil fungi and aerobic actinomycetes. Northwest Sci. 44:102-106, illus.

Application of ammonium chloride or sodium nitrate to the forest floor had no measurable effect on survival of *Poria weirii* in 2-inch wood cubes buried 8 inches deep but apparently did affect populations of aerobic actinomycetes at that depth. When the same chemicals were mixed with soil and potted with similar cubes, both substantially reduced survival of the pathogen.

145. Nelson, Earl E.
1972. Effect of urea and wood shavings on populations of soil microfungi, especially *Trichoderma* species. Microbios 5:69-72.

Urea and wood shavings mixed with soil individually or together increased populations of soil microfungi, whereas shavings on the soil surface had no effect. Only urea increased population levels of *Trichoderma*, however. Isolates of *Trichoderma* (97 percent *T. viride*) were highly antagonistic to *Poria weirii*.

146. Norgren, J. A., G. A. Borchardt, and M. E. Harward.
1970. Mt. St. Helens Y ash in northeastern Oregon and south central Washington. *In* Abstracts of the 43rd annual meeting, Northwest Scientific Association, Salem, Oreg., p. 66.

Stratigraphy, mineralogy, and particle-size data are given for a volcanic ash deposit found in forest soils along a transect between Mount St. Helens and Wallowa County, Oregon.

147. Norris, Logan A.
1970. Adsorption and desorption of four herbicides on forest floor material. *In* Abstracts of the 43rd annual meeting, Northwest Scientific Association, Salem, Oreg., p. 66.

148. Norris, Logan A.
1970. Degradation of herbicides in the forest floor. *In* Chester T. Youngberg and Charles B. Davey (eds.), Tree growth and forest soils, p. 397-411, illus. Third North Am. For. Soils Conf. Proc. 1968.

Amitrole, picloram, 2,4-D, and 2,4,5-T are degraded in forest litter but at markedly different rates. Constituents of formulation may retard the degradation rate of 2,4-D. When 2,4-D and DDT are applied together, the degradation rate of 2,4-D is briefly stimulated. Other interactions studied were not significant.

149. Norris, Logan A., and W. B. Bollen.
1971. Behavior of cacodylic acid and MSMA in forest floor material and soil. (Abstr.) *In* Precommercial thinning of coastal and intermountain forests in the Pacific Northwest, Feb. 3 and 4, 1971. Proc., Short Course., Wash. State Univ., Pullman.

150. Okazaki, Rose, Henry W. Smith, Raymond A. Gilkeson, and Jerry Franklin.
1972. Correlation of west blacktail ash with pyroclastic layer T from the 1800 A.D. eruption of Mount St. Helens. Northwest Sci. 46(2):77-89.

151. Owston, Peyton W.
1971. Containerized Douglas-fir grows well in peat moss-vermiculite mixtures. *In* Abstracts of the 44th annual meeting, Northwest Scientific Association, Moscow, Idaho, p. 10.

Douglas-fir grew better in peat moss-vermiculite mixtures than in sandy loam, peat moss, or combinations of Douglas-fir bark and vermiculite.

152. Paeth, R. C., M. E. Harward, E. G. Knox, and C. T. Dyrness.
1971. Factors affecting mass movement of four soils in the western Cascades of Oregon. Soil Sci. Soc. Am. Proc. 35:943-947.

Soils derived from greenish tuff were less stable than soils from reddish and yellowish tuff and had high amounts of smectite, no kaolin, and moderate amounts of free iron oxide. The more stable soils contained kaolin, more chlorite and chloritic intergrades, more free iron oxide, and less smectite. Clay in pseudomorphs in the silt and sand fractions was not active mechanically but did contribute to cation exchange and moisture retention. Color was correlated to clay mineralogy and slope stability.

153. Phillip, M. J., S. M. Beck, C. T. Youngberg, and C. M. Gilmour.
1974. Measurement of CO_2 evolution from the forest floor with an electrolytic respirometer. Am. Soc. Agron. Abstr., p. 177.

A battery-operated electrolytic respirometer was developed making it possible to measure CO_2 evolution from the forest floor in situ independent of root respiration.

154. Pumphrey, F. V.
1971. Grass species growth on a volcanic ash-derived soil cleared of forest. J. Range Manage. 24:200-203.

Grasses producing high forage yields in a 20- to 28-inch precipitation zone of northeastern Oregon on volcanic ash soil (Tolo silt loam) cleared of a stagnant forest were Greenar intermediate wheatgrass, Sherman big bluegrass, and Regar bromegrass. Tall oatgrass, meadow foxtail, and creeping meadow foxtail were high yielding when fertilized.

155. Radwan, M. A., G. L. Crouch, and H. S. Ward.
1971. Nursery fertilization of Douglas-fir seedlings with different forms of nitrogen. USDA For. Serv. Res. Pap. PNW-113, 8 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Ammonium sulfate, calcium nitrate, and urea fertilizers were tested in the nursery to determine the relative values of ammonium, nitrate, and urea as nitrogen sources for Douglas-fir. Seedling growth in the nursery and outplanting performance of the fertilized trees were essentially the same with the nitrate and urea, and both fertilizers were superior to ammonium.

156. Rice, R. M., J. S. Rothacher, and W. F. Megahan.
1972. Erosional consequences of timber harvesting--an appraisal. *In* Watersheds in transition, p. 321-329. Proc., Am. Water Resour. Assoc. and Colo. State Univ., Fort Collins.

Summarizes an understanding of the effects of timber harvesting on erosion.

157. Rickard, W. H., J. F. Cline, and R. O. Gilbert.
1973. Soil beneath shrub halophytes and its influence upon the growth of cheatgrass. Northwest Sci. 47:213-217.

Shrubs appear to provide a soil media richer in mineral nutrition than adjacent grass-dominated areas.

158. Riekerk, H.
1971. The mobility of phosphorus, potassium, and calcium in a forest soil. Soil Sci. Soc. Am. Proc. 35:350-356.

Radiotracers were sprayed on Douglas-fir forest soil simulating rainwash inputs. Fractions of radiotracers amounted to 10 percent of total phosphorus, 27 percent of total potassium, and 5 percent of total calcium leaching from the forest floor annually.

159. Riekerk, H.
1971. Movement of labeled nutrient elements in a forest soil-tree system. *In* L. R. Donaldson et al. (eds.), The Fern Lake studies, p. 49-53. Univ. Wash., Coll. Fish., Contrib. No. 352.

160. Rothacher, Jack.
1973. Does harvest in west slope Douglas-fir increase peak flow in small forest streams? USDA For. Serv. Res. Pap. PNW-163, 13 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Logging in Douglas-fir forests with deep porous soils has only minor effects on major peak streamflows which occur after soils have been thoroughly wet by fall rainstorms.

161. Rothacher, Jack, and William Lopushinsky.
1974. Soil stability and water yield and quality. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. D-1 to D-23, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

162. Ruth, Robert H.
1974. Regeneration and growth of west-side mixed conifers. *In* Environmental effects of forest residues management in the Pacific Northwest,

a state-of-knowledge compendium, p. K-1 to K-21. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Environmental requirements for regenerating west-side mixed conifers are described.

163. Schlichte, A. K., and F. C. Ugolini.
1972. Morphology and genesis of adjacent prairie and forest soils of the Puget Sound lowland. *In* Abstracts of the 45th annual meeting, Northwest Scientific Association, Bellingham, Wash., p. 12.

Soils formed beneath prairie and forest vegetation on gravelly glacial outwash deposits in the southern Puget Sound lowlands have dramatically different morphological features; however, their mineralization and chemical characteristics are similar.

164. Seidel, K. W.
1974. Natural regeneration of east-side conifer forests. *In* Environmental effects of forest residues management in the Pacific Northwest, a state-of-knowledge compendium, p. L-1 to L-25, illus. USDA For. Serv. Gen. Tech. Rep. PNW-24. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Favorable and unfavorable effects of forest residues and their treatment on natural regeneration of the coniferous forests of eastern Oregon and Washington are discussed.

165. Singer, M. J., and F. C. Ugolini.
1973. Chemical and mineralogical properties of two well drained subalpine soils. *In* Abstracts of the 46th annual meeting, Northwest Scientific Association, Walla Walla, Wash., p. 33.

Two soils from the International Biological Program intensive research site at Findley Lake are compared and contrasted.

166. Sommer, Hermann C.
1973. Managing steep land for timber production in the Pacific Northwest. J. For. 71:270-273.

167. Steinbrenner, E. C.
1971. Logging systems: Soil considerations influencing management policies. *In* Western reforestation, p. 21-23. West. For. and Conserv. Assoc. Proc., 1971.

168. Steinbrenner, E. C., and D. K. Lewis.
1973. Response of ponderosa pine to fertilizer applications. Am. Soc. Agron. Abstr., p. 142.

A complete (NPKS) treatment showed the greatest response on experimental plots near Klamath Falls, although there was significant response to all nitrogen treatments.

169. Strand, Robert F., and C. C. Grier.
1973. Seasonal model of litter decomposition in coniferous forests. *In* Abstracts of the 46th annual meeting, Northwest Scientific Association, Walla Walla, Wash., p. 35.

Describes a litter decomposition model developed for use in watershed modeling.

170. Strand, Robert F., and Richard E. Miller.
1969. Douglas-fir growth can be increased report from Pacific Northwest shows. For. Ind. 96(11):29-31.

171. Swanston, D. N.
1971. Principal mass movement processes influenced by logging, road building, and fire. *In* Forest land uses and stream environment, symposium proceedings, Oct. 19-21, 1970, p. 29-40, illus. Oreg. State Univ., Corvallis.

Dominant classes of soil mass movement active on watershed slopes in the Western United States are identified, and a simple movement mechanism described. The effects of logging, roadbuilding, and fire on mass movement occurrence are also identified and their importance as an erosion-accelerating agent evaluated.

172. Swanston, D. N.
1974. Slope stability problems associated with timber harvesting in mountainous regions of the Western United States. USDA For. Serv. Gen. Tech. Rep. PNW-21, 14 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Natural soil-mass movements on forested slopes in the Western United States include, in order of decreasing importance and regional frequency of occurrence: (1) debris slides, debris avalanches, debris torrents; and (2) creep, slumps, and earth flows. They result largely from slope loading (from road fill and sidecasting), oversteepened bank cuts, and inadequate provision for slope and road drainage.

173. Swanston, D. N., and C. T. Dyrness.
1973. Stability of steep land. J. For. 71(5):264-269, illus.

Factors controlling and contributing to surface erosion and mass soil movement on steep forested slopes are identified and described. Land management impacts and means of minimizing damage are discussed.

174. Swanston, Douglas N.
1971. Judging impact and damage of timber harvesting to forest soil in mountainous regions of western North America. *In* Western reforestation, p. 14-19, illus. West. Refor. Coord. Comm. Proc., Nov. 30, 1971. West. For. and Conserv. Assoc., Portland, Oreg.

Slope disturbance produced by forest operations on mountainous terrain has been identified as a major contributor to initiation and acceleration of erosion by soil mass movement processes. Roadbuilding is the most damaging operation, but timber cutting and slash burning are effective initiators in local areas. Factors controlling slope stability and current techniques for identification and control are discussed.

175. Tarrant, R. F., D. G. Moore, W. B. Bollen, and B. R. Loper.
1972. DDT residues in forest floor and soil after aerial spraying, Oregon--1965-68. Pestic. Monit. J. 6:65-72.

Of the 12 oz of DDT applied per acre on an eastern Oregon forest, about 26 percent reached the ground surface initially; over 36 months, about 6 percent more was brought to the ground in litter fall. No effect of DDT was noted on soil microbial populations, nitrification rate, or amount of nitrate nitrogen in the soil.

176. Tarrant, Robert F.
1970. Environmental consequences of using fertilizer and other chemicals in forest management. West. For. Pest Comm. Annu. Meet. Proc., p. 13-14.

The environmental impact of forest fertilization is not well defined, although knowledge indicates the effect should not be great. Forest resource managers, forest research administrators, and critics of the use of chemical tools used in forest management all share an obligation to improve their approach to matters affecting the environment.

177. Tarrant, Robert F.
1970. Man-caused fluctuations in quality of water from forested watersheds. *In* Proceedings of the Joint FAO-U.S.S.R. International Symposium on Forest Influences and Watershed Management, Moscow, U.S.S.R., August 1970, p. 209-218.

Changes in energy patterns, chemical or physical constitution, or abundance of organisms in forest waters that do constitute pollution most often result from man's activity.

178. Tarrant, Robert F.
1971. Nutrient release in streamflow from forest watersheds in relation to management practice. (Abstr.) Soc. Am. For. Annu. Meet., p. 4.

179. Tarrant, Robert F., K. C. Lu, W. B. Bollen, and J. F. Franklin.
1969. Nitrogen enrichment of two forest ecosystems by red alder. USDA For. Serv. Res. Pap. PNW-76, 8 p. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

In a coastal Oregon area, where soil nitrogen is perhaps near the maximum attainable in a forest environment, presence of red alder led to a threefold increase in the amount of nitrogen circulating in litter fall.

180. Tarrant, Robert F., and James M. Trappe.
1971. The role of *Alnus* in improving the forest environment. Plant and Soil, Spec. Vol., p. 335-348.

Worldwide experience indicates that alder contributes significantly to the supply of nitrogen in the ecosystem. This contribution markedly benefits soil fertility. A definite potential exists for using alder in forest management in much the same way as legumes are used in agriculture. Research indicates also that *Alnus rubra* may play a significant role in controlling *Poria weirii*, a virulent root pathogen which causes extensive losses of commercial timber tree species in western North America and Japan.

181. Thomas, B. R., G. H. Simonson, and L. Boersma.
1973. Evaluation of criteria for separating soils with xeric and udic moisture regimes. Soil Sci. Soc. Am. Proc. 38:738-741.

Soil and plant-water suctions were monitored in western Oregon under young conifers. Willamette Valley foothills had xeric soil-water regimes, and Coast Range mountain sites were udic. Xeric soils showed greater depletion of available water than udic soils at comparable stages of plant growth.

182. Tiedemann, A. R.
1972. Stream chemistry following the Safety Harbor forest fire and erosion control fertilization in north central Washington. *In* Abstracts of the 45th annual meeting, Northwest Scientific Association, Bellingham, Wash., p. 13.

The effect of fire and urea fertilization on stream chemistry was evaluated from measurements of nitrogenous constituents, chemical properties, and four cations for 1 year in streamflow from a burned watershed, a burned watershed fertilized with 78 kg/ha urea, and an unburned, unfertilized adjacent watershed.

183. Tiedemann, A. R., and H. W. Berndt.
1972. Vegetation and soils of a 30-year deer and elk exclosure in central Washington. Northwest Sci. 46:59-66, illus.

Vegetation and soils of a deer and elk exclosure maintained since 1939 were compared with an adjacent area of continuous game use in 1970. Despite the similarity of soil characteristics between the exclosure and outside, snowbrush ceanothus appears to have had an ameliorating effect on the exclosure because of the greater biomass and litter.

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Review of the Logging Residue Problem and Its Reduction Through Marketing Practices

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PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
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ABSTRACT

This study notes the increasing concern over logging residue in forest land management and describes the various administrative and technological means for accomplishing reductions of logging residue.

Alternative sales arrangements can include such things as reduction of stumpage charges for low quality logs or required yarding of unutilized material to the landing or to some stockpiling or disposal point.

Improvements in materials handling can include use of logging systems that create less breakage or that can handle small pieces more efficiently.

Specialized chip mills and increased chip markets, including chip exports, can give added incentive for removal of formerly unutilized material. Other potentials for utilization are also indicated.

Keywords: Logging economics, clearing operations (post-logging), forest residues.

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INTRODUCTION

Forest managers see a growing desire on the part of top levels of management, environmental agencies, and the general public to reduce the amount of logging residues. These residues are created in logging, and it is only natural to expect the logging process itself to pay for them or to carry out measures to reduce them. Thus, the sales arrangements contained in any timber sale contract are a critical element in how much of the total wood material is removed and paid for, and in how any remaining residues are to be treated.

Most logging residues in the Pacific Northwest were formerly burned. Now, however, public awareness of air pollution has focused attention on the unfavorable results of burning of logging slash--the tops, limbs, defective pieces, and broken chunks left after harvest. The smoke is plainly visible, and its source is obvious. Since timber cutting began, untreated logging residue from old-growth forests has been a fire threat and an obstruction to resource management. Many public viewers are now sensitive to the visual impact of smoke from slash burning, especially on otherwise clear days, and critical of the disorderly appearance of logging slash.

As part of the growing concern for the environment everywhere, a general attitude is emerging that environmental objectives must be given greater weight in all aspects of forest land management. These objectives include maintaining clean air, an uncluttered landscape, and a prompt return of harvested areas to a productive forest condition.

Greater utilization is an obvious solution to the problem of reducing the amount of logging residue on harvest areas; and greater utilization can come from stronger incentives in the timber selling process, more efficient materials handling and development, and new products or processes that utilize low-quality wood.

Another motive for reducing logging residue comes from the land manager himself. This is to clean up the land and make it more accessible for men and equipment for more intensive management of the next crop, a task becoming more real and more urgent as the general threat of natural resource shortages receives attention.

Our purpose in this report is to review potential for and problems of reducing logging residue, through improvements in timber selling procedures, materials handling, and product utilization. We will also examine the economic framework of residue reduction, current practices in residue management, recent studies and developments, and suggest possible improvements, primarily in sales arrangements.

Although this report focuses on reduction of logging residue, we recognize that on delicate or unfertile soils some of the smaller residue should be left as protective cover, for soil building, and for nutrient recycling (Cramer 1974).

QUANTITIES OF LOGGING RESIDUE

Howard (1973) estimated that on clearcut areas in 1969 in western Washington and western Oregon the average net volume of chippable residue ranged from 1,328 cubic feet per acre (93.0 m^3/ha) on private lands to 3,127 cubic feet per acre (218.9 m^3/ha) on National Forest lands (fig. 1). On the east side of Washington and Oregon, the averages were 352 cubic feet per acre (24.6 m^3/ha) for private lands and 291 cubic feet per acre (20.4 m^3/ha) for the National Forests. For both States, the total net residue generated during 1969 was 547 million cubic feet (15.5 million m^3).

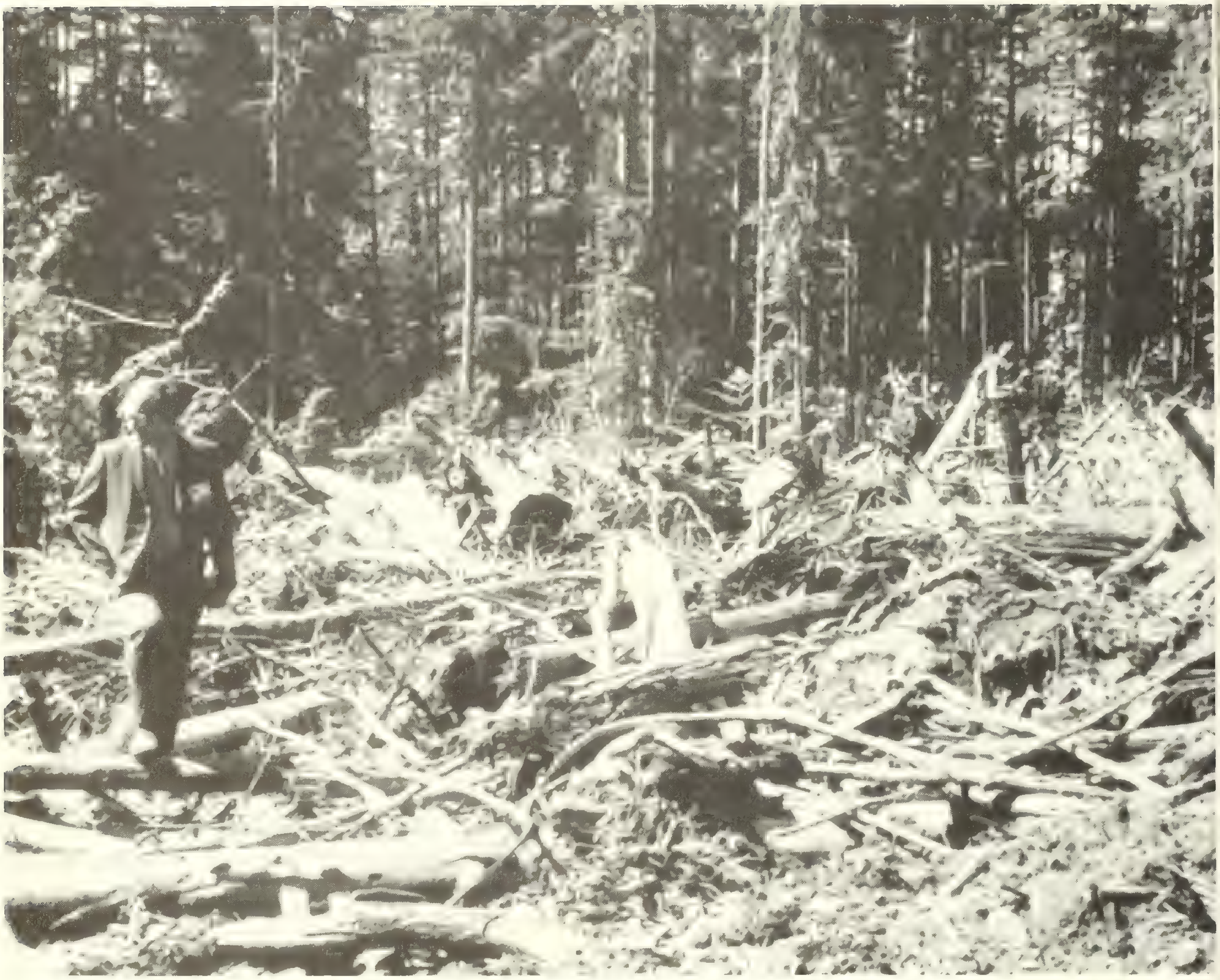

Figure 1.--Accumulation of debris can be large after stands of old-growth Douglas-fir are clearcut, Willamette National Forest.

These amounts of logging residue do not include limbwood or so-called fine residue--pieces less than 4 inches (10.2 cm) in diameter outside bark and 4 feet (1.2 m) in length. Although they may be a physical barrier to reforestation and represent a short-term fire hazard, they are excluded from discussion in the remainder of this report, primarily because of their low potential value for products.

LOGGING RESIDUE AND THE DEMANI FOR WOOD

The overall demand for wood produ in the United States has increased 65 pe cent in the last three decades, and a co tinuing increase is expected. With only modest increases in available timber harvests, the result will be a continuing pressure toward increasing prices of timber and timber products (USDA Fore Service 1973).

Part of the projected growth in demand
or wood could be met, and price pressures
ased, by increased utilization of both mill
nd logging residue, use of trees presently
lassed as culls, and increased efficiency
construction and manufacturing. Greater
fficiency in the utilization of residues
ould also contribute to wood needs, and
nprove public acceptance of timber har-
esting.

By way of perspective, coarse wood
esidues from manufacturing have been
creasingly utilized over the past two
ecades. The estimated volume of chips
eceived at pulpmills, mostly produced
om slabs, edgings, veneer cores, and
ther similar coarse material, has grown
om 0.1 billion cubic feet (2.8 million m^3)
olid-wood basis) in 1950 to 2.1 billion
ubic feet (59.4 million m^3) in 1973
leveloped from Phelps and Hair 1974).
ome of this mill residue, of course,
omes from increased utilization of logging
esidue, or of what would otherwise be
ft as logging residue.

In Washington and Oregon, consumption
y pulp and board mills increased strongly
r both utility grade logs and chips from
oundwood chipping mills (Bergvall and
edney 1970, Bergvall and Ormrod 1974,
lanock et al. 1970, Schuldt and Howard
974):

	Consumption of Utility grade logs	Consumption of chips from roundwood chipping mills
	(Million board feet Scribner scale)	(Thousand tons, dry weight)
968	177.8	75.6
972	481.4	2,041.4

Chip exports from the two States, from both roundwood and mill residue, increased threefold between 1968 and 1974 (Ruderman 1975):

	Chip exports
	(Million short tons, dry weight)
1968	1.2
1972	2.2
1974	3.6

THE ECONOMIC FRAMEWORK OF RESIDUE REDUCTION

Practical-minded men familiar with logging operations are often quick to point out that logging residues are left because they have no value, or even a negative value. They point to the gradual improvement in logging utilization over the years in response to higher prices and claim that it is useless to try to force more complete utilization of logging residue because this might only displace some other more suitable raw material.

This reasoning is partially valid, but it does not lead to a fully satisfactory conclusion. For one thing, it reflects only a short-term viewpoint and does not recognize that in the long run the total size of the market can be increased so that residue can be utilized without displacing other raw material. Moreover, innovative processes, products, and equipment can make efficient utilization possible. In this sense, channeling residues into more integrated manufacturing complexes will probably lead to expansion of the total market.

Also, this view does not recognize that socially desirable ends are not always achieved by market forces. Under favorable conditions, market forces can be changed by (1) shifting from average cost pricing of timber stumpage to some form of dual pricing where low value material goes at a cheaper rate, (2) reallocating fixed logging and manufacturing charges, and (3) channeling residues into more integrated manufacturing complexes where they can be put to a wider variety of uses.

In a sense, residue reduction is largely a physical accomplishment objective. It provides a symbolic demonstration of good land stewardship, professional management, and avoidance of physical waste. Advocates of cleaner logging assert that residue reduction should not have to yield a dollar return; it is regarded more as just another part of the harvest job, required by a commitment to quality land management.

Such reasoning may be used to justify more residue reduction in the form of disposal, but most people prefer greater utilization to a disposal treatment. Here, however, utilization at a cost greater than the value of the product would generally be considered a misallocation of resources. Clearly, the challenge is to develop new sales arrangements, materials handling, and utilization processes that lower costs or increase the demand for and value of potential products.

Management of logging residue is becoming a vital part of the forester's job. This involves chiefly a reduction of total amounts of residue where that residue is excessive. It also involves a planned effort to recognize the benefits of leaving some residue on the ground for soil building, soil stabilization, and nutrient recycling.

CURRENT PRACTICES IN RESIDUE MANAGEMENT

A variety of logging practices concerning utilization are in effect on lands of different ownership classes. These illustrate both the variety of conditions and the trial-and-error nature of efforts by different agencies and owners toward making residue reduction a part of the forest and land management job.

FOREST SERVICE

Management of the National Forests has always had implicit goals of protecti and stewardship of the environment, but in practice these have not always been easy to achieve.

Normally, timber sales are made o a competitive bid basis, after appraisal, with either (1) a bid price per thousand board feet for each species, with quanti based on scale recovery of the logs as they are removed, or (2) on a tree measurement basis, where bidding is on the basis of a total dollar amount for the sal as a whole. These two methods are called the scale recovery method and th lump-sum method.

Scale Recovery Method

In the scale recovery method, the bid price for each species or class of material applies uniformly to all the volume of each removed. This means that some logs are lower in value and some are higher. However, logs lower in value than the bid price may cost the purchaser more than they are worth, an he may be tempted to fell and buck the timber so as to produce a minimum of such logs. In addition, he might have little interest in removing marginally unsound logs, permitted without charge, because of the danger that, in scaling, these might be judged sufficiently sound (usually one-third or more) to require payment at the full bid price the same a the higher quality logs.

Historically, nearly all Forest Service imber sales in Region 6, the Pacific Northvest Region (Washington and Oregon), have een by the scale recovery method, rather han the lump-sum method. This is due hiefly to the purchaser's risk that any iven sale will produce less than its estinated volume, and to the desire of both eller and purchaser for scaling records or inventory control and for other purposes.

In the last few years most Forest ervice sales on the west side of the ascade Range have had mixed pricing, vith logs of 80 board feet and larger net cale subject to pricing on a scale recovry basis, and smaller logs or logs less han one-third sound priced at a low fixed ollar amount per acre.

Although opportunities are limited, purchaser could alter his bucking ractices so as to throw some of the tandard scale-recovery material into he substandard per-acre material and scape payment for it, even though he emoves it. As far as can be determined, his has not occurred to any great extent.

Tree Measurement or Lump-sum Sales

In the tree measurement or lump-sum ethod, the total price is fixed, and there s no charge for additional material taken ut, large or small, cull or sound. In eory this should encourage greater tilization because the extra stumpage ost for any extra piece is zero. An dvantage of this method over the combined cale recovery and per-acre pricing rrangement is that in the complete tree easurement sale there would be no centive to alter the bucking practice to ivert more logs into the cull or per-acre ricing category. A disadvantage is the ore intensive cruising required for cceptable accuracy in measurement of mber volume.

Up to now, Region 6 of the Forest Service has made relatively few tree measurement sales.

Yarding of Unutilized Material

Required yarding of unutilized material, called "YUM yarding," has been used since 1969 on portions of designated Forest Service timber sales. Most sales using this arrangement specify that all substandard logs of a given diameter or larger (usually 8- or 12-inches (20.3- or 30.5-cm) diameter inside bark at the large end) and 10 feet (3.0 m) or more in length must be yarded to landings or to specified locations on the sale area (fig. 2).

From the standpoint of the land manager, there are four major purposes for YUM yarding. First, the smoke from broadcast slash burning can be reduced or eliminated, particularly in the smoke sensitive period of early fall. The YUM piles will burn hotter and can therefore be burned later in the season, on overcast days when not visually objectionable, and on days when air movement is away from population centers. Piles burn with less smoke than a broadcast ground fire, and the higher temperatures from combustion will carry the smoke to higher atmospheric levels for dispersion.

Second, this serves the land manager's objective for greater utilization because the cost of YUM yarding enters the appraisal as a fixed cost and the operator's only extra costs are those of loading and hauling. Third, YUM yarding makes the area more accessible to men and machines for reforestation, thinning, and other management activities. Finally, the cleaner, well-groomed look is more esthetically acceptable to the public (fig. 3). Other purposes have been discussed by Combs (1975).

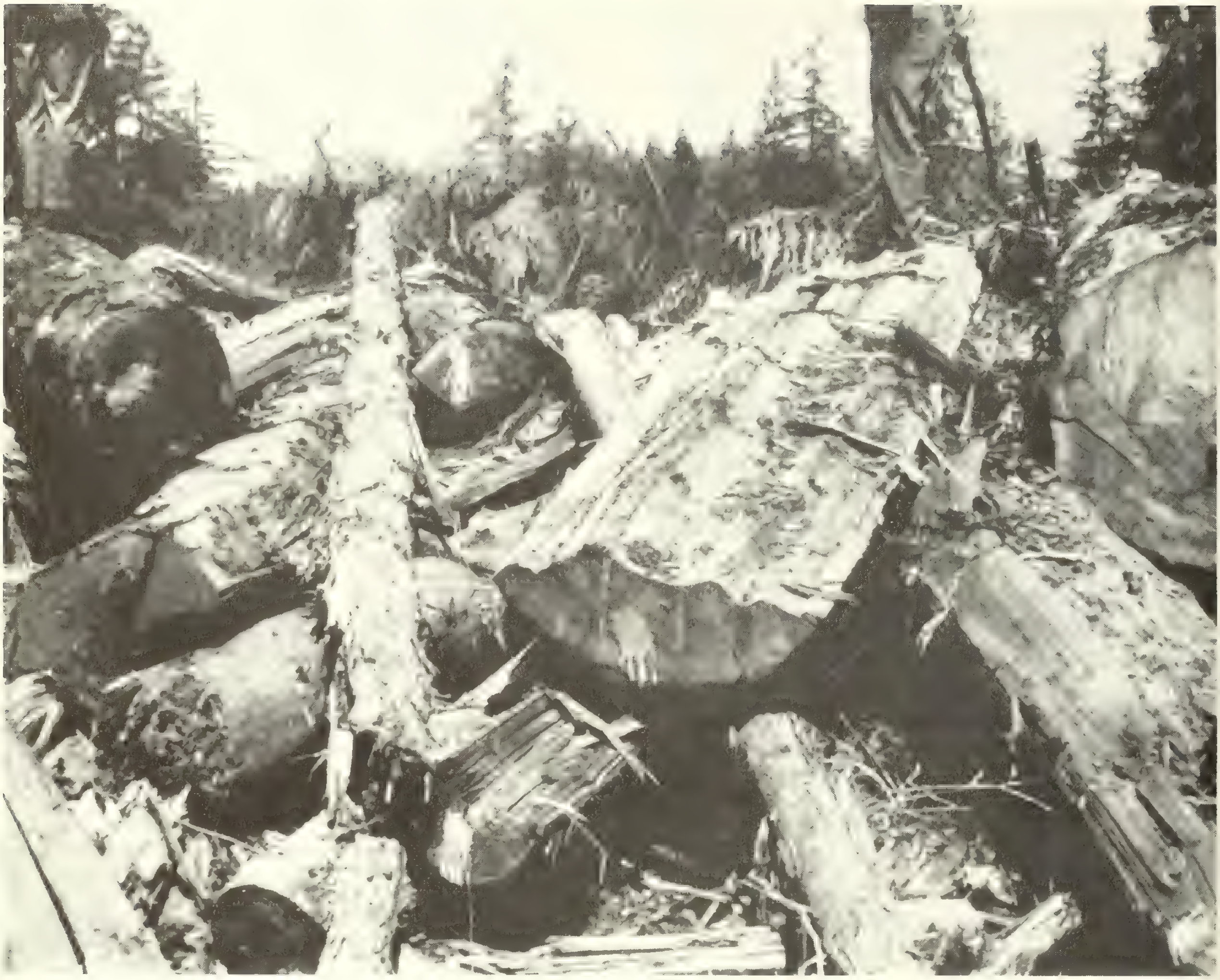

Figure 2.--Unmerchantable material yarded to landing, Willamette National Forest.

Potential advantages of YUM yarding to the purchaser are that it provides more total work and appraisal cost allowance for his men and equipment, and potentially provides more raw material for industry. An additional advantage of YUM yarding would accrue if an efficient operator should find he can do the extra yarding work for less than estimated in the appraisal. Finally, a strategic advantage can be recognized where the purchaser, after developing a chip mill or a specialized small log sawmill able to utilize this extra material, could have an edge over competitors not having such an integrated outlet.

The purposes of YUM yarding are understood by timber purchasers and operators, but these persons often dislike doing the job, especially when other more productive logging jobs are available. Some suggest that YUM yarding might be better handled by the Forest Service or as an entirely separate contract. Others contend that actual costs have sometimes exceeded estimated costs.

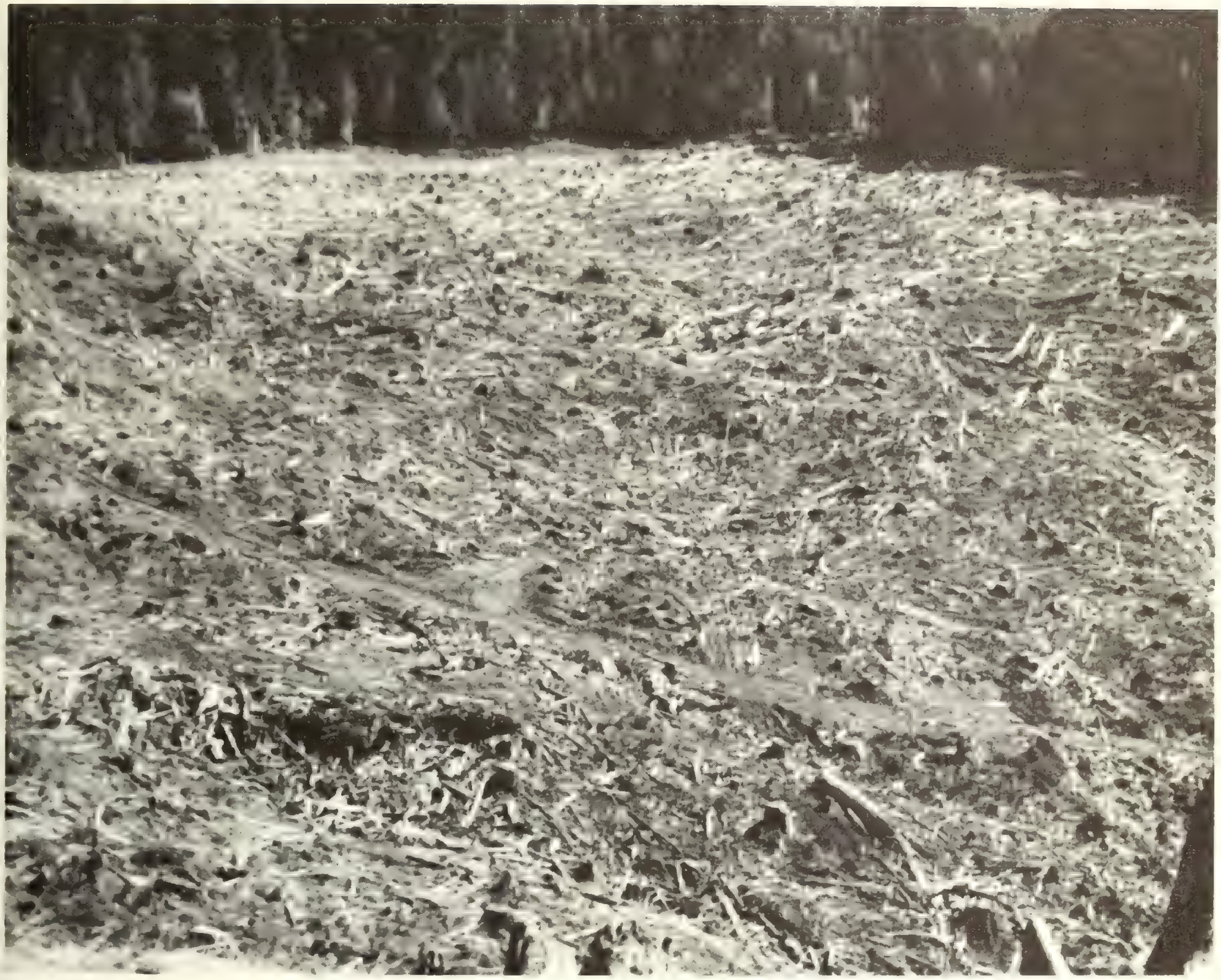

Figure 3.--Clearcut area after unutilized material has been yarded, Willamette National Forest.

Other criticisms of YUM yarding are that (1) it does not really eliminate the need for broadcast burning of fine material and competing low vegetation which are deterrents to reforestation, (2) the remains of burned YUM piles are unsightly and these often burn so hot that soil damage may occur, and (3) costs of up to $500 per acre are questioned as being greater than benefits (Dowdle 1973).

YUM yarding is probably not a universal land management prescription, but it has been at least partially successful in achieving its objectives. Although the cost appears high compared with other treatments, it is justified by land management benefits and by the incentive it gives for additional utilization of the resource.

BUREAU OF LAND MANAGEMENT

Timber on BLM, U.S. Department of the Interior, lands is nearly always sold on a lump-sum basis. No standards for cutting and removal of pieces to a stated minimum size need be included in the sale contract. After he has paid for the entire timber volume, the purchaser has an incentive to remove all material whose revenue exceeds the costs of removal.

The BLM requires slash disposal on nearly all timber sales. Burning is the primary means of slash disposal. Gross yarding, a term analogous to the Forest Service's YUM yarding, is authorized for use in locations where it is desirable as a means of preparing the area for reforestation or where there is a smoke-management problem.

STATE OF WASHINGTON

The Washington Department of Natural Resources has a vigorous program of timber sales on State forest lands. Most of their old-growth timber in western Washington is sold on a scale recovery basis.

In May 1971, the Department of Natural Resources publicized a proposal to develop an assured, stable market in northwest Washington for large Utility grade logs[1] and for small sound logs or chunks to a minimum size of 4 inches by 8 feet (10.2 cm by 2.44 m). Through competitive bidding, a processing firm would be guaranteed a 10-year supply of such material, up to 40 million board feet (188,800 m^3) annually, at a guaranteed uniform delivered price, subject to price adjustment every 2 years. The firm would operate a pulp-chip mill and presumably other facilities to rebuck Utility grade logs so as to salvage sound segments that would have higher value for lumber and veneer.

Some established purchasers of timber opposed the plan because they felt they already had developed a good market for fiber logs and did not want to give up this advantage. Others claime that the mechanism for sorting and gradi logs was uncertain and the mechanism fo price adjustment too cumbersome. The proposal has not yet been activated.

STATE OF OREGON

The State of Oregon has almost no old-growth forests under its management and therefore does not experience the large amount of defect or heavy breakage that contributes to the major slash and residue problems on other ownerships. State-owned timber in Oregon is sold under both the scale recovery and the lump-sum methods, the latter used main in the more uniform young-growth stands

Slash disposal on State of Oregon forest lands is done by the timber operat Where necessary, slash concentrations are treated by piling and burning, spot burning, or by broadcast burning.

INDUSTRY LANDS

The comments which follow are based largely on discussions with representatives of three large industrial landowners. This type of landowner exerts more control over utilization of wood, from tree stump through all stages of processing, than do smaller landowners or the public agencies. This is a decided advantage in land management for residu reduction.

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[1] A Utility grade log is one that does not meet the requirements of Peeler or Sawmill grade logs but has a usable chip content of at least 50 percent of its gross volume, a minimum diameter of 6 inches (15.2 cm), and generally a minimum length of 12 feet (3.7 m) (Columbia River Log Scaling and Grading Bureau et al. 1972).

On private lands with controlled access, the results of logging are viewed less by the public; and in remote locations esthetics understandably may receive less consideration. Industrial landowners, in contrast to stumpage purchasers, are in a position to obtain the benefits of reduced hazard, easier reforestation, and better access for subsequent land management, and they have an economic interest in recovering maximum timber volume from each acre.

Utilization

Industry lands are often closer to log markets than are public forest lands. This lowers transportation costs and tends to make closer utilization more feasible.

A key to logging residue reduction lies in marketing, in finding ways to utilize the less valuable pieces rather than spending money to dispose of them. For a large integrated manufacturing firm, every addition to the supply of wood raw material adds opportunity for profit in the manufacturing and marketing process. Also, large firms with their own logging crew often pay wages on an hourly basis, thus eliminating the logger's incentive to leave small and defective logs of low value for larger and more valuable timber elsewhere.

More Efficient Log Handling

Large industrial firms have achieved closer logging utilization by: (1) sorting logs in central log yards under close supervision to assign each log to its highest value use, depending on mill needs or orders; (2) bucking logs at a central yard to raise grade; and (3) increasing logging efficiency, with each step more under the landowner's control than occurs under public timber sales.

REVIEW OF RECENT STUDIES

Several studies in the last few years have dealt with the problem of logging residue. The following review of these studies traces the growing recognition of logging residue as a problem in resource management and helps to establish why reduction of logging residue is becoming a working objective of forest management.

Feasibility Study in Western Washington

In 1964 the Gram Development Corporation reported on the economic feasibility of utilizing logging residue in selected Washington counties (Gram Development Corporation 1964). This study examined several locations for a chipping plant or a combination chipping plant and sawmill. The conclusion was that a specialized operation could be feasible, but logs would have to be obtained on favorable terms; a close working relationship would be necessary between timber buyer and seller and a location near an integrated forest products industry complex would be desirable.

Forest Residues Problem Analysis and Research Program

Fahnestock[2/] prepared a research problem analysis on impacts of forest residues and their disposal. His conclusion was that management systems should be devised to encourage more utilization, charging part of the added costs against the direct and indirect benefits to land management. This analysis stimulated formation of the Forest Residues Program at the Pacific Northwest Forest and Range Experiment Station.

[2/] Fahnestock, George R. 1968. Impacts of forest residues and their disposal on forest land management and environment in the Pacific Northwest. In-Service report, Pac. Northwest For. and Range Exp. Stn., Portland, Oreg. 28 p.

Forest Management in Wyoming

An interdisciplinary Forest Service study team investigated the management of four National Forests in Wyoming, in response to public concern of current practices (USDA Forest Service 1971). Principal findings were that people are concerned about the full range of forest values, about unfavorable effects of timber harvesting, and about the quality of forest stewardship. They found that much of the criticism could be attributed to inadequate, improper, or poorly timed treatment of logging residue.

They recommended research on possibilities for greater utilization or treatment, studies on effects of logging residue management on water quality, and more coordination of burning with meteorological information so as to reduce objectionable effects on air quality.

Study of Prospective Residue Utilization

In 1971, a consulting firm, H. C. Mason and Associates, prepared a report for the Pacific Northwest Forest and Range Experiment Station on prospective utilization of substandard log material.[3]

Factors identified as contributing to successful operations included: stronger chip markets, flexible management policies, close working relationships with timber sellers and logging operators, a stable market, and an outlet for accumulations of higher grade logs or log segments. Part of the success of an operation in logging residue would rest on the opportunity to buck out higher value segments from otherwise Utility grade logs.

In one sense, removal of logging residue was viewed as a service function. It was suggested that the desirability of cleaning up the woods may be worth some form of purchaser credit on stumpage.

The required yarding of unusable cull logs was considered discouraging to operators, and charred log remains at the landing or other location are apt to be more detrimental to appearance of the site than if left in place throughout the uni

Close Timber Utilization Committee Report

In 1971 a Forest Service committee o close timber utilization prepared a procedure for making close timber utilization a stronger part of Forest Service management direction. Their report noted that even though the Forest Service has had a long-standing policy to obtain the closest utilization economically practical, the present national concern for environmenta quality indicates that greater efforts are now required (USDA Forest Service 1972c)

Their main recommendations were to:

1. Prepare interim standards that specify target levels of residue reduction according to different conditions of fire hazard, public exposure, and other factor
2. Defer timber harvesting where these standards cannot be met.
3. Extend application of already available practices which encourage better utilization, including lump-sum sales, YU yarding, multistage logging, and service contracts with salvage rights.
4. Study alternative timber sale arrangements including sale of logs at the roadside or at a concentration point, use of an extended land management contract, and alternative pricing procedures to avoid average cost pricing of low-value materia

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[3] Mason, H. C., E. M. Matter, G. O. Tolman, and R. C. Smith. 1971. Study of prospective utilization of substandard log material. 35 p., illus. H. C. Mason and Assoc., Inc., Gladstone, Oreg.

5. Require residue removal under a 'prudent land manager'' concept, which gives greater recognition to the total management needs of the landowner.

6. Give greater priority to research and development of methods for reducing logging residue.

7. Encourage improved utilization on State and private forest lands, establish regional teams to promote better utilization on all lands, and implement a 5-year effort to reduce logging residue substantially on all forest lands.

National Forests in a Quality Environment

A nationwide review of environmental aspects of National Forest timber management was made by a multidiscipline team of Forest Service staff specialists (USDA Forest Service 1972b).

Recommendations involving logging residue were: (1) to increase Forest Service sensitivity to esthetic values in planning and executing timber harvests and related activities, (2) to design and apply silvicultural treatments to selected road foregrounds in a manner that would perpetuate appropriate species and provide an attractive roadside, (3) to recognize areas where the final harvest cut must be deferred until markets and sale procedures assure a reasonable level of utilization of he timber, and (4) to accelerate research n key program areas, one of which includes research in practices to enhance the environment and reduce unfavorable impacts on it.

Forest Service Response to Recommendations of Forestry Deans

The Forest Service responded in June 972 to the recommendations of five foresry school deans who had evaluated clearcutting on the National Forests in a report to the Council on Environmental Quality (USDA Forest Service 1972a). The deans recommended improvement in Forest Service timber sale administration and supervision, greater contract flexibility, and more effort toward increased logging utilization. They also recommended research for improved logging systems and for better ways of slash disposal and removal of logging debris.

The Forest Service response recognized public concern over the "harsh visual aspect" of a patch-cut area and outlined steps being taken to give more attention to environmental quality and to study alternative mixes of various uses that National Forests can provide. Reduction of logging residue, either by utilization or by some form of disposal, is being given greater emphasis as an important policy objective.

Report of the President's Advisory Panel on Timber and the Environment

In an appendix to a report by a special advisory panel on timber and the environment, Newport (1973) outlined possible changes in timber sale policies to improve logging utilization and reduce waste. These included more thinning and salvage sales, more sales on a lump-sum or tree measurement basis, and pricing policies to provide for sufficient profit and volume to encourage investment in new equipment and processes especially designed for small logs and defective logs.

A staff paper for the advisory panel's report also explored a service-type contract for Federal timber sales, with a logging contract separate from the log sale contract and a reduced stumpage charge for low value logs, compensated by higher charges on high value logs, or by purchaser credit for noneconomic removal of small or defective material.

The purpose of both these reports was to suggest methods for reducing logging residue through new forms of sales arrangements.

Status of Timber Utilization Report

Grantham (1974) reviewed the status of timber utilization on the Pacific coast and pointed to technological advances in yarding systems, log sorting centers, new pulping systems, new structural products, and more accurate sawing as means to reduce wood residues.

He discussed recent advances in wood combustion technology including predrying, reduction to uniform-sized fuel, improved combustion control through furnace or boiler design, and improved exhaust emission control. Suggested uses were for direct heat exhaust to veneer dryers and dry kilns, or to boilers for electric power generation by some of the larger forest industry plants, especially pulp mills and papermills. Application of these technological advances can contribute to greater logging utilization.

Studies of Lump-sum and Per-acre Pricing

In western Oregon, a 1970 study compared six each of scale-recovery and lump-sum sales and found no significant difference between the two groups with respect to volume of logging residue, costs of sale preparation and administration, and bid prices (Beuter and Arney 1972). Observed differences, however, suggested the possibility that other factors such as type of equipment, market situation of the logger, and time of logging may have had a strong influence on logging utilization.

Another study of 1971 logging on National Forests in western Washington and western Oregon compared 19 scale recovery sales with 19 sales where logs of 80 board feet in volume and over were sold on a scale recovery basis but all smaller, cull, and Utility grade logs wer included on a lump-sum per-acre basis (Hamilton et al. 1975). Results showed an adjusted average of 16.8 percent less residue on the lump-sum per-acre sales, statistically significant at the 10-percent probability level but not significant at the 5-percent level. The authors concluded that this was weak statistical evidence of a real difference between the two method and that other factors surrounding the harvest operation may be more importan

IMPROVED SALES ARRANGEMENTS

Several variations in timber selling procedures have been described earlier in this report. These include scale recovery sales, lump-sum or tree measurement sales, sales to specified utiliza tion standards, combination per-acre an scale recovery sales, and sales with required yarding of unutilized material. Several marketing aspects inherent in the timber selling process are:

1. The sales contract is a legal agreement between independent parties to do what is specified in the contract. It is difficult to specify every detail precisely in a contract and yet retain the flexibility needed for common sense decisions and efficient operation.

2. Timber purchasers have a primary interest in obtaining logs for their manufacturing business or for resale. Logging operators, to continue in busines must produce adequate and sustained income; this directly depends on high-volume log production. For the purchase or logging operator, logging costs rise sharply for small or low-quality material Most logging residue has little or no valu to these parties.

3. One of the principles of marketing is that to accomplish something through another party you must find a way to make him significantly better off. Reduction or removal of logging residue is not easy under this principle.

4. If logging residues on public lands are to be significantly reduced, the public somehow will have to stand the cost, either in reduced stumpage receipts or in higher product prices.

The above marketing aspects raise the question of what actions might be taken to modify the sale procedure to help achieve greater logging utilization. Alternatives have been considered, and additional research or pilot testing is needed. Some promising ideas are:

TUNE UP PRESENT SYSTEM

Some actions can be taken to improve logging utilization under current authority and regulations. Any effort to intensify or modify management prescriptions will take time for refining and testing. This, however, requires direction and support from top levels of management of both sellers and buyers.

Rapid closeout of cutting units for resale may also encourage residue removal. Resale may be either for relogging of parts of the unit, or more probably, for sale of YUM piles.

INCREASED SLASH DISPOSAL DEPOSITS

Increased purchaser deposits under the Brush Disposal Act (16 U.S.C. 490) could provide for additional residue reduction work. At present, these deposits are collected primarily for fire protection work, where objectives are not as broad as the residue management objectives which relate to the total impact of residues on other uses and the environment.

REQUIRED REMOVAL

Before introduction of per-acre pricing for logs under 80 board feet in size, the utilization standard specified in Region 6 Forest Service sales was generally to a 50-board-foot net log size in old-growth stands and to 20 or 30 board feet in young-growth or intermediate-age forests. Operators were expected to remove all logs down to the minimum size standard. Larger pieces not removed would be scaled and paid for at a penalty rate.

Initial experience under the per-acre pricing for material under a given minimum size has not been uniform. Some operators were encouraged to remove more of the small material, since it bears no direct stumpage charge, but other operators left such material, preferring to move to more valuable material in another sale. When per-acre pricing was first introduced, there was no strong requirement to remove the per-acre material. However, in July 1974, the Forest Service in Region 6 adopted an arrangement under which pieces down to 30, 20, or 10 board feet in individual sales were required to be removed. With Utility, Special Cull grade,[4] and hardwood logs, an exception was made for gross economic impracticability at the time of removal of other timber. Much residue material, however, does not meet these specifications and is not affected by required removal of the specified material.

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[4] The Douglas-fir Special Cull grade includes logs that do not meet the requirements of Peeler and Sawmill grade rules but are suitable for rotary cutting and have surface characteristics of a good No. 2 Sawmill log. In addition, they must have an adjusted gross diameter of at least 16 inches (40.6 cm) and adjusted gross length of 8 feet 8 inches (2.6 m); they must contain at least 60 percent usable material of firm white speck or better (Columbia River Log Scaling and Grading Bureau et al. 1972).

The Washington State Department of Natural Resources has similar removal requirements in most of its current contracts.

Where insufficient space is available on regular landings, nearby storage areas might be provided to hold YUM material, particularly Utility grade and Special Cull logs during a poor market period. Although the idea of storage areas has much appeal, possible problems include size of storage area, length of storage period, conflict with other potential uses of the storage site, accountability of logs if more than one purchaser uses the same storage area, susceptibility to insect, disease, and fire hazard, and what to do with logs still in decks at the contract expiration date.

SERVICE CONTRACT

Under a service contract, the public land management agency would in effect hire the operator to do the logging job as directed and deliver logs to a sorting yard or to a third party. This would give the public agency more control over logging, which could then be more flexible than under the present system of stumpage sales. Any degree of residue removal could be required because the operator would be paid to do the work. The payment to the operator could be from a revolving fund or purchaser credit toward other timber, or some form of third party payment to the operator.

LAND MANAGEMENT CONTRACT

The land management contract would focus attention on the land management job rather than on the logging job. The contracting firm would be given a high degree of responsibility and control and would need capability in a broad range of land management skills in addition to logging skills. Residue management would be considered a part of this land management job. For example, a curren timber sale on the Wind River Experimental Forest specifies a desired residue level to be left on three clearcutting units rather than giving specifications for mini- mum size pieces to be removed. It is up to the purchaser to reach this desired level with the yarding process.

An advantage claimed for the land management contract concept is that the contractor's success would be related to how well he does the land management job rather than how fast and how cheaply he gets out the logs.

Rather than specifying the details of operation, the contract could require that operations be carried out in accordance with an approved annual logging plan whic would contain the details and be subject to negotiation and change each year without modification of the basic contract.

Potential disadvantages of this conce include inflexibility because of the probab long-term nature of commitment, possibl loss of control over detailed operations by the agency, and difficulty of defining precisely the responsibilities of the contracting parties, particularly those which might differ from the present timber sale contract. Lack of capability to perform technical work might exclude some operators or firms from qualifying for such a contract.

MATERIALS HANDLING

Some logging residues constitute a materials handling problem in yarding, where heavy, expensive logging equipmen is not suited to handling small or defectiv pieces. Logs and chunks are also left as residues when the operator doesn't have a market for the total range of available raw material. Improvements in material handling can therefore increase utilization and thus reduce logging residue.

Conventional logging equipment is not
ways suitable for protection of land values
n steep slopes nor for use under partial
utting prescriptions. Improved logging
ystems are therefore needed to reduce the
hysical impact of the logging process and
create less residue.

WO-STAGE LOGGING

Two-stage cutting or yarding may
rove feasible, in which heavy equipment
used for large logs, and smaller more
exible equipment and crews for smaller
eces. However, stage cutting has
ndency to cause breakage in felling the
econd stage because of numerous stumps
ft from the earlier stage.

Part of the advantage of two-stage log-
ng, similar to adding a small sawmill
longside a large sawmill, is that the large
g handling system can be relieved of
andling smaller logs, which are more
ostly with the large equipment. This
llows the large-log system to operate
loser to its full capacity and avoids wast-
g time with smaller logs.

The second stage logging can remove
ot only the small logs impractical to
andle with the larger system but also
ome of the logs that either system could
emove. Therefore, the second stage log-
ing can also operate more efficiently by
aving a larger volume over which to
pread fixed costs (Adams 1965).

ORE EFFICIENT LOGGING SYSTEMS

Ordinary timber sales are seldom
eared to a rational integration of the log-
ing and manufacturing process in an
fficient total system. Availability of an
creasing diversity of logging methods
ow calls for more skill in sales layout
nd more coordination with types of equip-
ent used. Efficient logging also bucks
ogs and sorts species, sizes, and grades
o meet the various requirements of the manufacturing plants involved. Logging residues tend to be reduced when logging is integrated more closely with the diversity of utilization outlets available.

The conventional high-lead system has an inherent tendency to create residue by breaking logs when pulling them out of a jammed situation and when they hang up against stumps and other logs or roll down a sidehill in yarding. On the other hand, skyline systems create less residue because they can suspend logs or lift one end higher during the in-haul to the landing. Thus, there is less interference from intervening stumps and slash. Balloon and helicopter systems have this capability, but their high cost of operation increases the size of the log that is economically submarginal and might be left as residue.

Grapple systems are faster than choker systems and can permit more rapid and thus cheaper handling of low-value material that might otherwise be left as residue. However, grapple systems are mostly limited to clearcutting.

Skidding or yarding is just part of the materials handling process. More efficient loading can sometimes be accomplished by cold-decking small-diameter or short pieces for later handling by a smaller loader than used for the larger logs. Hauling of small-diameter or short pieces can be inefficient or even impossible with standard long-log trucks unless there are sufficient bunk logs to support the load. Short truck and trailer combinations have been developed, with stakes set to accommodate short logs. An extra trailer and a loading crib can be used to accumulate the next load while the main truck and trailer is on its way to the mill (Adams 1965). However, except for strictly salvage or large integrated operations, keeping such equipment fully occupied on a daily basis is difficult.

COMBINED LUMBER AND CHIP MILLS

Special sawmills have been designed to operate on a high proportion of Utility-grade logs. Such mills aim to increase value recovery of the logs by rebucking long logs into better grade segments suitable for lumber or veneer production. Value recovery is increased from what would otherwise be largely pulp logs or culls.

Such mills must be designed to handle a large volume of chips, preferably with a whole-log chipper available. They also require a market outlet for the large accumulations of sawdust, rot, and bark usable only as hogged fuel.

Keys to successful operation are low capital investment, a limited product line, small crew, a dependable log supply, and a firm outlet for chips and hogged fuel.

A conventional sawmill cannot afford to operate in this fashion, because the investment in equipment and high labor cost requires use of largely sound material from which volume and value output is greater.

MOBILE CHIPPERS AND SATELLITE PLANTS

Large mobile chippers have been used successfully for conversion of small logs to chips at the logging site but have been made largely obsolete by introduction of chip-and-saw mills, or by other small-log mills that are able to make a higher value product for small sound logs. Smaller mobile chippers are now available, but these find difficulty in producing chips that can compete with mill residues in the chip market.

Independent chipping plants have also been tried but generally have not been successful because of a fluctuating chip market. These mills seem to be the first affected in a poor market because of their inability to make other higher val products in combination with the chippi operation. Other chip mills, integrate with larger forest industry firms, have been more successful and probably will increase in number.

The chief advantage of mobile chipp and satellite chipping plants is that they reduce raw material to chip form early the marketing process, thus avoiding costly handling and rehandling of many individual small irregular-shaped-piec

Mobile chippers and satellite chipp plants also have the disadvantages of geographic separation from the utilizati plant and lack of business and marketin efficiency when the chipping facility is i separate ownership from the utilization plant. Further disadvantages of mobile chippers, in particular, are their need for an independent power source, costly transportation of workers to remote sit delays caused by weather, and the difficulty of servicing breakdowns away fror parts and servicing sources.

EXPANDED MARKETS

Reduction of logging residue throug greater utilization ultimately depends o enlarging the market for end products that can use such material. In the shor run, logging residue is left on the loggir site because it cannot compete with high value raw materials already in use. On a technical breakthrough, higher log prices, or a larger total market can bring more of this low-value material into use.

Small, sound logs down to a 5-inch (12.7-cm) top diameter may be utilized in chip-and-saw or other specialized small log sawmills. For material not ited to lumber or plywood use, the chief arkets are chips for domestic pulp or rticleboard or for export. Other poten- al outlets might be as raw material for ectric power generation or mulch and oil conditioner.

HIPS FOR DOMESTIC PULP OR ARTICLEBOARD

It is true that much logging residue ontains a large amount of sound fiber. owever, in normal times pulpmills have een well supplied by mill residue and tility grade logs. Also, much of the ound fiber in existing logging residue is ixed with partially or totally decayed ber or is in irregularly shaped pieces ot suitable for handling and debarking, nd costs of collecting and handling are xcessive for this less suitable material.

The 1973-74 slump in the lumber ndustry sharply reduced available mill esidues, and the pulp industry turned trongly to logging residue as a supple- ental source of chips. Several large hip mills were built, and these will robably continue operating even when vailability of chips from mill residue esumes. However, sharp fluctuations n the chip market can disrupt any general rogram for increased residue utilization.

The particleboard industry is growing ather strongly, but from only a modest ase relative to volume of all wood used y industry. Its principal markets are in he East and Central States, and raw aterials closer to these markets have a ransportation advantage, plus a labor ost advantage in many cases. If the ublic were to share a part of the cost of elivering raw materials to the particle- oard industry as a residue disposal easure, expansion of the particleboard ndustry might be more feasible.

Structural flakeboard is a new type of board in the developmental stage. Its main features are longer flakes (1-1/2 to 3 inches (3.8 to 7.6 cm) long) and controlled orientation of the flakes to give the product greater strength. Douglas-fir flakes are especially well suited because of their improved strength properties. If development is successful, this product could greatly enlarge the market for wood residues. Its principal use would be for wall and roof sheathing in the housing and construction markets.

CHIPS FOR EXPORT

The chip export industry, exporting chiefly to Japan, is well established on the west coast and is expected to continue strong except for minor fluctuations. Long-term contracts (about 7 years) are presently in force, and in the long term some expansion of this market is possible. So far foreign purchasers have been interested mainly in dealing with large well-established firms that can assure a long-term dependable supply.

ELECTRIC POWER GENERATION

Use of logging residue for electric power generation has been investigated by the Pacific Northwest Forest and Range Experiment Station (Grantham et al. 1974). The study found that this potential use is severely limited by the high cost of collecting and transporting large volumes of residue to a generator site. Use could be either in power stations in the 25- to 50-megawatt size class, or in industrial power plants such as those at pulpmills where there is a demand for process steam as well as electric power. Larger sawmills and plywood plants also have need for substantial amounts of electric power as well as for heat energy for kilns or veneer drying. At present, these latter uses show much promise for increased use of residues. However, none of these can realize the full economy of large scale powerplants, which with other fuels will occur more in the 500- to 1,000-megawatt size class.

Electric power generation from logging residue in the Pacific Northwest was found potentially feasible only if the public were to absorb a portion of the costs of collecting and transporting the residue material. Electric power generation is a low-value use for logging residue. Generally it cannot compete with higher value uses for sound fiber for pulp or particleboard. This situation may change if demand and price for electric power continue to increase. Other objectives, such as environmental cleanup and the building of diversity or reserve capacity into our total power system, could overcome a costwise disadvantage.

Burning of wood residue in combination with municipal refuse to generate power might be feasible once a decision was made to handle municipal refuse in this manner, but the technology for this use has not yet been well perfected. A 115-megawatt plant of this nature has been proposed for Lane County, Oregon (CH2M Hill 1973).

OTHER ENERGY USE

The 1973 worldwide oil crisis created much interest in developing other sources and types of fuel, such as methanol for automobiles (Reed and Lerner 1973) and methane gas from municipal organic wastes or animal manure. Wood residues also could be converted to these products, yet many technical and logistic problems would have to be solved before suitable processes could be economically feasible on any large scale (Grantham and Ellis 1974). At present, all evidence points to other sources of energy being much cheaper and accessible in larger quantities, su as coal or natural gas as a primary methanol source.

MULCH AND SOIL CONDITIONER

Bark mulch is used extensively for landscaping purposes, but whether chip logging residue could ever be competiti in this use is questionable, mainly beca bark is already available at a very low cost at mills and because the color and texture of bark mulch is more esthetica pleasing.

Highway Use

Chipped logging residue may be suitable for highway roadside mulching, where appearance factors are not as critical as in other landscaping use. T purpose would be to conserve soil mois for landscape planting, to control growt of weeds, and to prevent erosion. On t negative side, highway mulch could be somewhat of a fire hazard during dry periods, but selective use may be feasi where potential benefits are high and th fire hazard low.

Chipped logging residue would have to be delivered to highway departments at a cost competitive with bark mulch now already available at low cost from mill residues (Mater 1971). Some port chippers are already in use by highway departments for disposal of roadside br and small trees.

Agricultural Use

Physical and chemical properties o bark make this material suitable for agricultural use (Bollen 1969). Trials have been made of bark and other wood residues used as an orchard mulch

Cruikshank 1971). Benefits to the crops ould have to be determined. Besides the bvious high cost, there would usually be nitrogen deficiency that would have to e monitored and corrected. With logging esidue, some undesirable as well as esirable fungi or other microbiota might e introduced.

The use of chipped logging residue orked into the soil as a conditioner, in ontrast to a mulch placed on the surface, another possibility. Here the nitrogen eficiency would be more serious. Any ecision on this use will depend on the enefits to farming, not the benefits of esidue reduction. Agricultural scientists ave given only brief consideration to this se of wood residues. So far, it appears npractical, particularly from the cost tandpoint (McGauhey 1971).

Chipped logging residue could be xplored for long-term soil building in xcessively sandy or clay-type soils cking organic matter, not as a commer-ial practice but as part of a public effort reclaim land not now suited to agricul-ral use. This could apply to situations here irrigation development of desert nd needs supplemental application of rganic matter to the soil. On the other and, a simpler plowed-under cover crop ould probably do as well at much less ost.

Forest Use

Scattering chipped logging residue ack on the logging areas would help ecycle nutrients and prevent soil erosion, ould cause nitrogen deficiency, and on teep ground would be extremely costly, not physically impossible. If the preading were restricted to what could e reached along existing roads or spurs might be physically or silviculturally easible, but still very costly in collecting and handling. Roadside chipping of slash from partial cutting or right-of-way cutting has been tried, but this method was found to be approximately 12 times more costly than slash burning (National Industrial Pollution Control Council 1971). In addition, scattering chipped logging residue on the logging site and along roads would usually increase the fire hazard.

Where roadside hazard is high, a protective strip adjacent to the road might be excluded with chips placed only beyond this strip. On little-used spur roads or secondary roads, a protective strip might not be necessary.

CONCLUSIONS

Our conclusions are intended to highlight the current situation and to bring the various aspects of the residue problem into focus:

1. Increasing public travel in the forest and increasing public concern for the environment make former levels of logging residue and smoke from slash burning more and more objectionable. Realistically, logging residue and slash burning can be reduced but not eliminated. Perhaps the public would accept these things more readily if given a better understanding of what was being done and why. From a conservation standpoint, utilization of logging residue is preferred over treatment or disposal methods.

2. Logging residue is lower in value and much more costly to handle than sound material with which it competes. However, in the long run, as market forces gradually increase the total size of the market and as the stumpage cost of sound logs increases, there will be a gradual increase in utilization of the type of material that is now logging residue. Any incentives that can be provided through improved sales arrangements, materials handling, and

utilization processes can speed adjustment to a changing market.

3. From the user's point of view, logging residue is often the highest cost source of raw material and tends to bear the greatest impact resulting from fluctuations in demand. In some instances, however, its low stumpage cost may offset higher logging costs.

4. Some changes in timber sale arrangements such as lump-sum pricing, required removal, and elimination of road maintenance charges for residue-type material can encourage increased logging utilization, but there is no universal solution, and a broad range of alternatives is desirable.

5. Despite its high cost, YUM yarding may sometimes be the only residue reduction measure available to the land manager. It has been an effective land management measure, especially in reducing residue and slash burning. However, it may not be desirable on steep, fragile soils or where landing space is limited.

6. Increasing demand for wood and the need to reduce residues has brought development of specialized log handling equipment, sorting yards, and chip mills to handle the lower grade material. As these become more common, the utilization of residues will work its way more and more into the permanent industrial and marketing structure and create a continuing demand for what is now residue.

7. The electric power industry is oriented toward large-scale hydro, nuclear, or fossil-fuel plants for economies of scale in preference to smaller, higher cost generating plants that might be based on use of wood residues. However, as the cost of purchased energy increases, forest-oriented industrial users such as pulpmills are finding it advantageous to generate more of their own electric power, heat, and processing steam from wood residues. Use of available wood fuel reduces dependence on purchased fossil fuels or purchased power, both of whic may be cut off in times of low supply.

8. At present, sound wood fiber has a higher market value for pulpwood chips, particleboard, or chip exports than as hogged fuel for electric power generation. However, when logging residue is used for these products a sizable proportion of bark, rot, and other material suitable for hogged fuel will also be produced.

9. Integrated firms that find a way to utilize logging residue will have a competitive edge over those that don't, even though the return from residue uti zation itself is not attractive.

10. Public benefits from reduction of logging residue and reduction of slas burning can justify public sharing of the costs of such reduction. In addition to onsite benefits, these benefits include the addition to the raw material base an the additional employment generated.

11. Not all logging residue should be removed, nor are all residues neces sarily objectionable. Some level of residue is generally beneficial, dependi on soil and site characteristics.

12. Continuing studies are needed of specific localized situations where a combination of favorable factors can make more residue utilization feasible.

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Forest Practices and Streamflow in Western Oregon

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PORTLAND OREGON

ABSTRACT

Forest management activities, including roadbuilding, clearcut logging, and broadcast burning, can change certain portions of the forest hydrologic cycle. Watershed studies and other hydrologic research in the Coast and western Cascade Ranges of Oregon have shown that these changes may increase annual water yield up to 62 centimeters, double minimum flows in summer, and increase fall peak flows up to 200 percent and small winter peak flows up to 45 percent in small watersheds. Changes in streamflow resulting from clearcut logging had little effect on either onsite damage to stream channels and hydraulic structures or downstream flooding when yarding caused only light disturbance of soil. By increasing the size of larger peak flows, roadbuilding and soil compaction may cause onsite damage in small, headwater basins. Increases in annual yield and minimum flows may be substantial on small watersheds that are clearcut; under sustained yield forest management, such increases are masked in large, parent watersheds by unaltered streamflow from unlogged watersheds.

KEYWORDS: Watershed management, streamflow, road building (forest logging (temporary)).

This paper was presented at the Symposium on Watershed Management, Logan, Utah, August 11-13, 1975.

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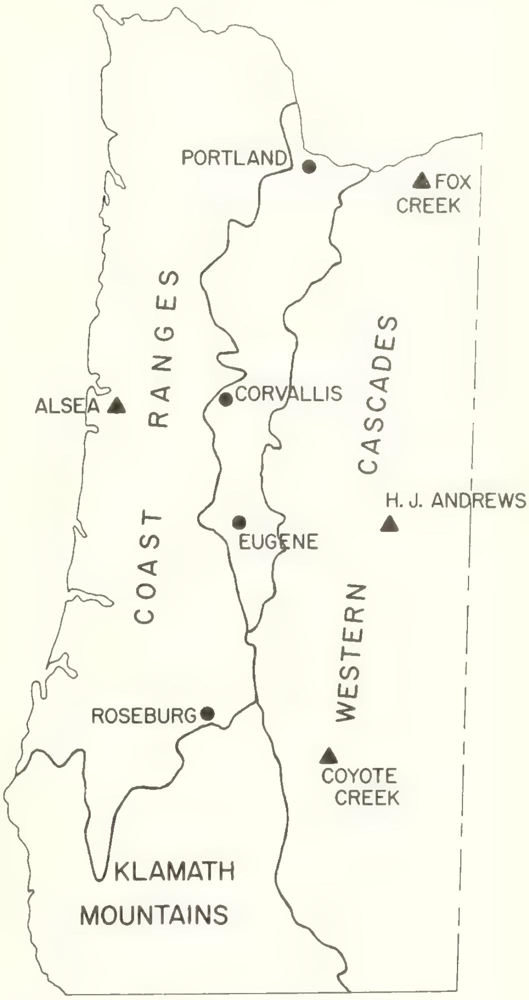
Introduction

Timber is a major resource of western Oregon, and the State's economy is largely based on timber harvest and wood products manufacturing. Each year some 7.5 million cubic meters (m) of timber are harvested from National Forests alone in western Oregon. In some National Forests more than a third of this total has been harvested with ground-based systems, and soil compaction can be extensive (Dyrness 1965). There are over 23 000 kilometers (km) of forest roads, and each year an additional 900 km of roads are constructed. Clearcutting has been the usual method of harvesting, after which slash has commonly been disposed of by broadcast burning. Because of possible effects of roadbuilding, timber harvesting, and burning on streamflow, a number of watershed studies were begun in western Oregon in the 1950's and 1960's. This report summarizes results from four of these studies and discusses application of results to land management problems.

Western Oregon can be divided into four physiographic provinces that illustrate its varied geologic history: the western Cascades, the Coast Ranges, the Klamath Mountains, and the Willamette Valley (fig. 1). Two of these, the western Cascades and the Coast Ranges, are areas of major timber harvesting and contain all the watershed studies. The western Cascade province is underlain mostly by basalt, andesite, and pyroclastic materials. The Coast Ranges province is underlain mostly by bedded sediments. The Willamette Valley, an area of alluvial agricultural soil, and the Klamath Mountains, a geologically complex province containing sedimentary, volcanic, and metamorphic rocks with intrusions of granite and serpentine, will not be discussed further here.

Most of western Oregon lies within the western hemlock (*Tsuga heterophylla*) zone (Franklin and Dyrness 1973), the most important zone in terms of timber production. Much of this zone supports subclimax forests of Douglas-fir (*Pseudotsuga menziesii*) mixed with western hemlock and western redcedar (*Thuja plicata*). In addition, Sitka spruce (*Picea sitchensis*) is found along the coast, and Pacific silver fir (*Abies amabilis*) is found at higher elevations in the western Cascades.

Figure 1.--Location of watershed studies and physiographic provinces in western Oregon.



The climate of western Oregon is greatly influenced by the Pacific Ocean. Temperatures are mild, and prolonged cloudy periods are common.

Winters are wet, and summers are relatively dry. Precipitation, occurring mainly in long-duration, low-to-moderate intensity frontal storms, ranges from 170 to 300 centimeters (cm) in the Coast Ranges and from 70 to over 350 cm in the western Cascades. From 75 to 85 percent of annual precipitation occurs between October 1 and March 31, mostly in the form of rain. Above 900-m elevation, accumulations of snow are common.

Annual streamflow is closely correlated with annual precipitation. Runoff is usually greatest in December and January, the months of maximum precipitation. At elevations where accumulations of snow are common, annual streamflow may exhibit two peaks, one resulting from rain in December and a second one resulting from snowmelt in April or May. Maximum runoff events in western Oregon have resulted from excessive rainfall concurrent with snowmelt in December and January. Such events have caused considerable damage to stream channels, hydraulic structures, and property in much of the region (Rothacher and Glazebrook 1968).

The four study areas described here are considered representative of much of western Oregon. The Alsea study was conducted by Oregon State University in the Coast Ranges about 16 km from the Pacific Ocean (fig. 1). Soils here are derived from marine sandstone and are 60 to 140 cm deep and extremely permeable (Corliss 1973). Physiography is typical of much of the Coast Ranges; slopes are steep (40 to 110 percent), topography is highly dissected, and V-shaped drainages are common. The three other studies have been conducted by the U.S. Forest Service, Pacific Northwest Forest and Range Experiment Station. The Fox Creek study is located within the city of Portland municipal watershed 40 km east of Portland. Soils here are silt loams or gravelly loams derived from basic igneous glacial tills which overlie andesite and basalt. Soils here also exhibit rapid to moderately rapid percolation rates.[1] Although steep slopes range up to 60 percent adjacent to streams in the lower ends of these study watersheds, the topography of this study area is relatively gentle with slopes less than 10 percent. A second U.S. Forest Service study is located in the H. J. Andrews Experimental forest 75 km east of Eugene. Slopes here are steep (55 to 110 percent), and soils are gravelly loams and clay loams derived from pyroclastic rocks. Soil permeabilities are extremely high (Rothacher et al. 1967), and runoff is rapid. Similar slope and soil conditions exist at Coyote Creek, the site of the fourth study included in this report. Soils are derived from tuffs and breccias and are quite permeable (Richlen 1973). Study areas are further compared in table 1.

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[1] Stephens, F. R. 1966. Soil management report, Bull Run-Sandy area, Oregon. 136 p. Unpublished report, USDA For. Serv., Mount Hood National Forest, Gresham, Oreg.

Table 1--*Characteristics of four watershed studies conducted in western Oregon*

Watershed study	Elevation range	Annual precipitation		Annual streamflow as percent of precipitation	Timber species
		Type	Amount		
	m		*cm*		
Alsea	135- 490	Rain	254	76-84	Douglas-fir Red alder
H. J. Andrews	455- 915	Rain	229	56-63	Douglas-fir Western hemlock
Coyote Creek	730-1070	Rain	117	30-43	Douglas-fir Mixed conifer
Fox Creek	840-1070	Rain Snow	284	60-93	Douglas-fir Western hemlock

Changes in Streamflow

Before we look at changes in streamflow resulting from certain forest management practices in western Oregon, let's briefly review the forest hydrologic system and isolate possible components that may be responsible for changes in streamflow. This hydrologic system, commonly referred to as the forest hydrologic cycle, is depicted in figure 2. Precipitation that falls on a forested area is subject to interception by plant surfaces. Some intercepted water eventually falls from plant surfaces and joins precipitation falling directly to the forest floor,

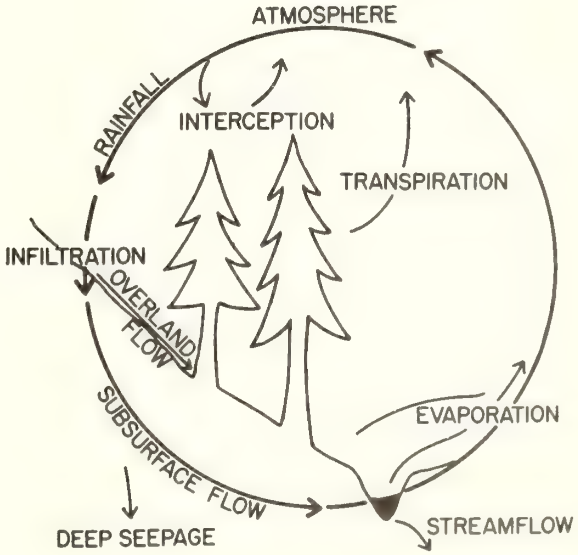

Figure 2.--Forest hydrologic cycle.

while another portion evaporates. In the H. J. Andrews area, about 14 percent of annual precipitation or about 30 cm is intercepted and evaporated (Rothacher 1963). The relative amount of storm precipitation "lost" to interception by a given forest vegetation depends mainly on the size of the storm. For example, Rothacher (1963) found this loss was 100 percent of storms less than 1.5 millimeters (mm) and less than 5 percent of storm precipitation in excess of 200 mm. In other words, a high proportion of precipitation from larger storms reaches the ground regardless of the presence of forest vegetation. Consequently, timber harvest would be expected to have its greatest effect on interception during smaller storm events.

In undisturbed forested areas in western Oregon, infiltration capacities are extremely high and storms are of long duration with low-to-moderate intensities. Surface soils frequently exhibit hydraulic conductivities in excess of 150 centimeters per hour (cm/h) (Dyrness 1969, Ranken 1974, Yee 1975). More important, unsaturated conductivities of at least the top meter of soil are sufficient for soils to transmit all precipitation during most storm events (Yee 1975, Harr 1975). Thus, for undisturbed soil, the overland flow component in figure 2 is virtually nonexistent; the movement of subsurface water accounts for nearly all streamflow in western Oregon. A small amount of streamflow, of course, does result from precipitation intercepted by stream channels.

When soil is disturbed by road construction, tractor skidding of logs, or broadcast burning, its infiltration capacity may be so seriously reduced that not all water will enter the soil. Some water may become overland flow which can move rapidly to stream channels and out of the watershed. In a few cases, the quantity entering the soil after compaction could conceivably be so small that soil drainage during the summer would be insufficient to maintain streamflow. Such cases may have been the origin of the popular but erroneous belief that clearcutting dries up springs and streams.

Water in the soil is subject to uptake and transpiration by forest vegetation and to evaporation from the soil surface. Generally, evaporation from soil under forested conditions is minimal, primarily because of small amounts of energy available for water vaporization at the forest floor and because of reduced air movement here. This energy situation can be drastically changed by timber harvest, and evaporation from soil is generally increased after removal of forest vegetation. However, this increase is greatly offset by a reduction in transpiration after timber harvest so that soil on a cut area will contain much more water at the end of a growing season than it did while forested. Water not returned to the atmosphere by evaporation or transpiration moves slowly downslope and maintains streamflow during rainless periods.

Subsurface water may be affected by construction of roads on steep slopes which may intersect relatively slow-moving subsurface water and convert it to more rapid surface flow in a ditch. This water and water flowing from road surfaces during storms moves rapidly through the ditch-culvert system and may reach the watershed outlet more quickly than it did before road construction.

With the foregoing hydrologic system in mind, let's now look at changes in streamflow which have been noted after common timber harvesting activities have been carried out in western Oregon.

ANNUAL YIELD

Increased water yields have been observed in clearcut watersheds at all four study locations, and in the partially cut watersheds at some locations. Figure 3 shows increases in annual yield after a 96-hectare (ha) watershed (HJA-1) in the H. J. Andrews Experimental Forest was clearcut. Logging began in August 1962; but because of operational difficulties with the fixed skyline yarding system, yarding was not completed until October 1966, at which time the watershed was burned. A statistically significant increase in water yield did not occur until 1963, when 40 percent of the watershed had been clearcut. After 100 percent of the watershed had been clearcut, annual yield was increased 46 cm from predicted (Rothacher 1970); the first year of 100-percent clearcutting, 1965, may not show a typical first year increase because of the occurrence of two extreme runoff events--Rothacher (1970) considered the 1966 and 1967 water years more representative of postlogging conditions. A general decreasing trend is apparent as regrowth has occurred. Although it is still too early to predict when increased water yields will cease, the trend in figure 3 suggests at least 20 years will be required.

In the Alsea study, the Needle Branch watershed (AL-1) was 82 percent clearcut in 1966 and burned in 1967. In addition, roads occupied about 5 percent of this watershed. Initial increases in annual yield reported by Harris (1973) are included with subsequent data in figure 4. Maximum increases did not occur the first year after logging or even the first year after burning. Increases of more than 60 cm occurred in 1969 and 1971, at least 2 years after logging or burning. Here, a trend of decreasing magnitude of yield increases is not readily apparent. Reforestation is proceeding here, but currently the watershed cover consists mainly of herbs and grasses with red alder (*Alnus rubra*) along stream channels.

A second watershed (HJA-3) in the H. J. Andrews study was 25 percent clearcut in patches after 8 percent of the watershed was initially cleared and roads were constructed. Figure 5 shows that annual increases in water yield averaged about 17 cm during the initial 5 years

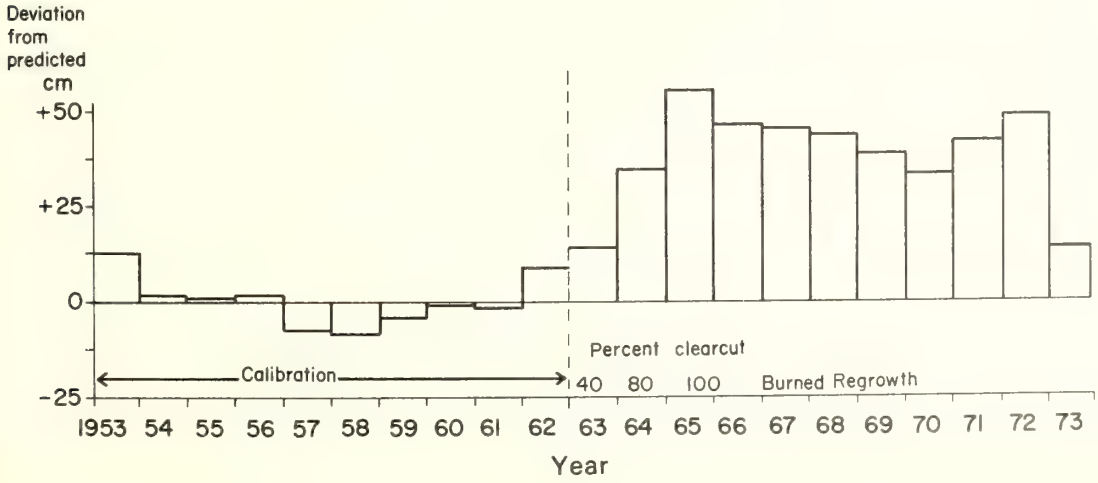

Figure 3.--Increases in annual water yield after clearcut logging in watershed 1, H. J. Andrews Experimental Forest.

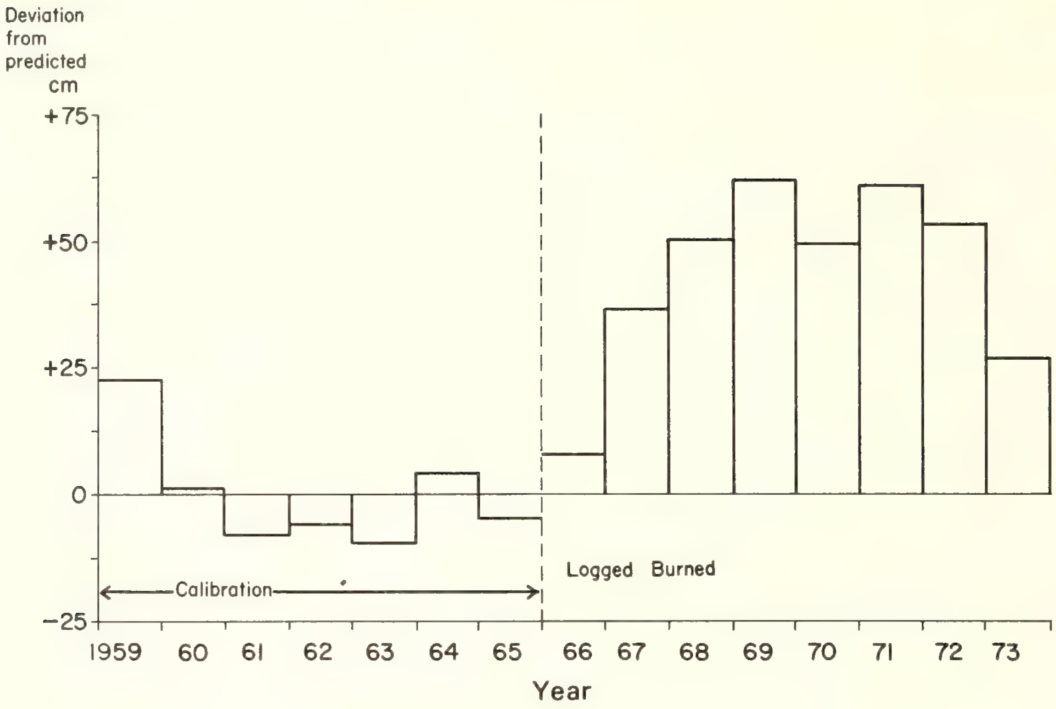

Figure 4.--Increases in annual water yield after 82-percent clearcut logging in Needle Branch watershed, Alsea watershed study.

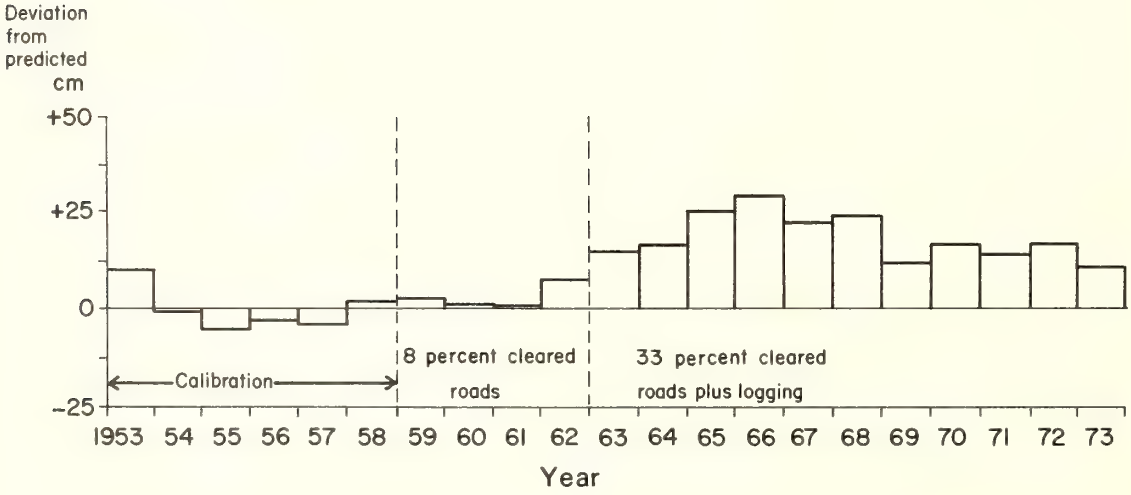

Figure 5.--Increases in annual water yield after roadbuilding and patch-cut logging in watershed 3, H. J. Andrews Experimental Forest.

after logging (Rothacher 1970, 1971), less than half the increases noted on the clearcut watershed. Subsequent increases have remained at about that level through 1973, although a slight decreasing trend is apparent. A second Alsea watershed (DC-3), which contained roads and was 25 percent clearcut in patches, similarly exhibited smaller yield increases than those noted on the 82-percent-clearcut watershed nearby.

Increases in annual yield of water after timber harvesting activities are summarized in table 2 for all the watershed studies in western Oregon. The two largest average percentage increases were noted on watersheds most extensively clearcut. The largest average percentage increase in water yield after roadbuilding and harvest occurred on the 100-percent-clearcut Coyote Creek watershed (CC-3). Here, yield was increased an average of 70 percent, but only 2 postharvest years of data are available. Also, soil on 13 percent of this watershed was compacted during windrowing of slash, and the overland flow that occurred certainly played an important role in the increase in annual yield. No statistically significant change in water yield was noted in two other Coyote Creek watersheds (CC-1 and CC-2) that were 30-percent cut by the shelterwood and patch-cut methods nor in the two Fox Creek watersheds that were 25 percent cut in patches.

In summary, results of water yield studies have indicated that extensive clearcutting in small watersheds in western Oregon may increase annual water yield more than 50 cm. This increase is slightly above the practical upper limit of yield increases expected from denuding an entire watershed that was

Table 2--*Summary of increases in annual water yield in western Oregon*

Watershed	Code	Size	Cut	Treatment[1]	Yield increase		
					Maximum	Average	Average increase
		ha	*Percent*		*cm*	*cm*	*Percent*
Alsea (Needle Branch)	AL-1	71	82	CC-R	62	49	27
Alsea (Deer Creek)	AL-3	303	25	PC-R	15	7	5
H. J. Andrews	HJA-1	96	100	CC	56	38	34
H. J. Andrews	HJA-3	101	33	PC-R	27	18	17
Fox Creek	FC-1	59	25	PC	--	[2]	--
Fox Creek	FC-3	71	25	PC	--	[2]	--
Coyote Creek	CC-1	69	30	SW-R	--	[2]	--
Coyote Creek	CC-2	68	30	PC-R	9	[2]8	24
Coyote Creek	CC-3	50	100	CC	37	33	70

[1] CC = clearcut, R = roads, PC = patch cut, SW = shelterwood.

[2] No significant change.

proposed by Hibbert (1967). In most cases, yield increases have been 25 to 35 percent of predicted streamflow.

SEASONAL YIELDS

Often the distribution of increases in water yield through the year are of more interest than the size of the annual increases. Analyses of seasonal increases in water yield have been made in three of the watershed studies in western Oregon; results are sufficient to describe, at least relatively, seasonal increases that can be expected in much of western Oregon.

The most complete analysis of seasonal water yields was made by Rothacher (1970) and later updated (Rothacher 1971). Increases in yield were noted for all seasons after a 96-ha watershed (HJA-1) was clearcut and burned. In much of the western Cascades and elsewhere in western Oregon, largest increases have occurred during fall months when soils on the cutover areas are wetter than they were under forested conditions. Thus, a smaller proportion of fall rains is required for soil moisture recharge and a larger proportion can go to streamflow. Smaller increases in yield observed during winter months generally have reflected differences in interception between cut and uncut areas, although in some cases differences in soil moisture may exist between cut and uncut areas because of winter transpiration. Increases noted in spring months have been due primarily to differences in soil moisture content as a result of transpiration. Summer increases have been small in absolute terms but large in relative terms. For example, minimum flow during the week of lowest flow doubled after watershed HJA-1 was clearcut, and tripled after this watershed was burned (Rothacher 1971). Two years after burning, however, increases had diminished as riparian and other vegetation returned.

Increases in minimum flows were also observed in the Oregon Coast Ranges. Harr and Krygier (1972) used the number of low-flow days, i.e., days with average flow below 0.011 cubic meter per second per square kilometer ($m^3/s \cdot km^2$) (1 csm[2/]) as a criterion for evaluating changes in minimum flows. A significant reduction in number of low-flow days was observed for 5 years after a 71-ha watershed (AL-1) was 82 percent clearcut and burned (fig. 6). As regrowth has proceeded, the trend has been toward the prelogging numbers of low-flow days. Effects were initially most pronounced in spring and fall. Because average daily flow during the summer was generally less than 0.011 $m^3/s \cdot km^2$ on even the 82-percent-clearcut watershed, an increase in streamflow during summer months could not be detected by this method of analysis even though an increase in streamflow undoubtedly did occur. A nearby watershed (AL-3) that was 25 percent clearcut showed a less consistent reduction in number of low-flow days, again primarily during spring and fall months.

Minimum flows at Coyote Creek were also increased after a 50-ha watershed (CC-3) was 100 percent clearcut. However, no significant changes were detected either on the Coyote Creek watersheds cut in small patches or by the shelterwood method or on the two patch-cut Fox Creek watersheds.

In summary, increases in seasonal water yield after timber removal are greatest in fall and spring when maximum differences in water storage (interception + soil water) exist. Largest relative increases occur during minimum flow in the summer.

[2/] csm = $ft^3/s \cdot mi^2$.

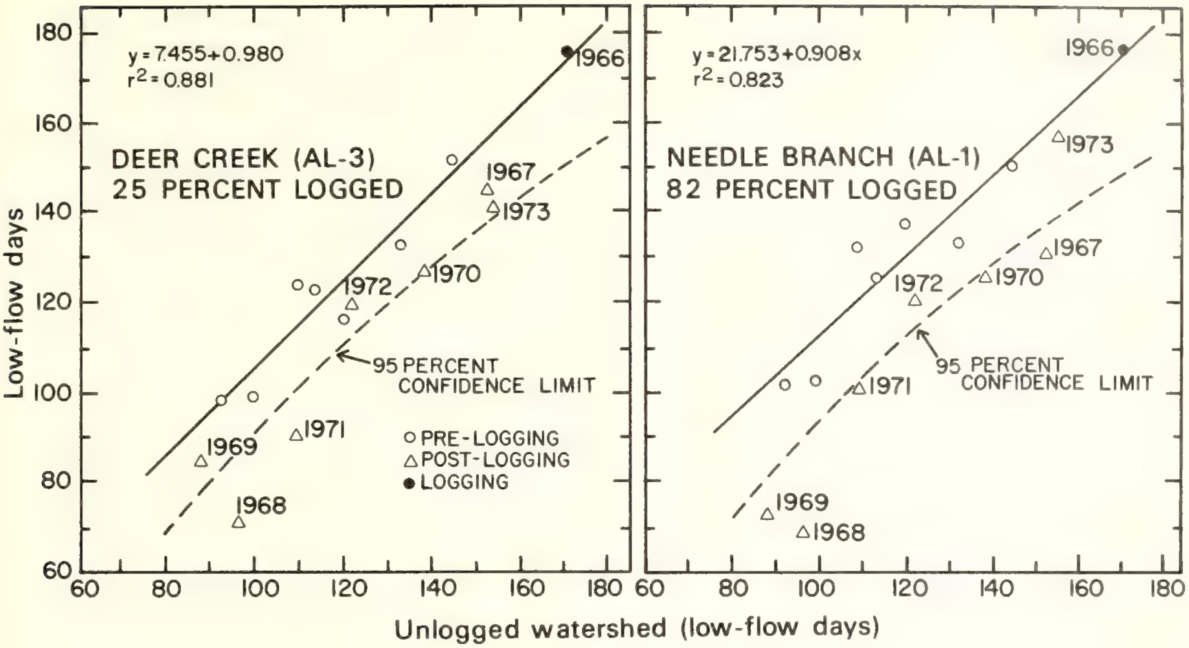

Figure 6.--Relationship between logged watersheds and an unlogged (control) watershed on low-flow days in the Alsea watershed study.

STORM RUNOFF

There has been continuing speculation about the influence of timber harvesting activities on the magnitude and frequency of floods in western Oregon. Anderson and Hobba (1959), for example, suggested that clearcutting in two major drainages in western Oregon increased peak flows 13 to 56 percent. More recent research, however, has indicated that, although smaller peak flows are indeed increased, major runoff events are little changed by clearcutting. Evidence does suggest that the effects of soil compaction on forest roads and skid trails in some regions may be much more serious, particularly for larger runoff events.

There are two characteristics of a runoff event which may be instrumental in causing some type of damage: peak flow and stormflow volume. Peak flows, i.e., the highest instantaneous rates of streamflow attributable to particular rainfall or snowmelt events, are generally responsible for damage to stream channels, hydraulic structures, and other improvements in headwater areas. Thus, any increases in major peak flows after harvesting can result in an increase in onsite damage. An increase in smaller peak flows, i.e., flows with a return period of less than that of the mean annual event, should not cause appreciable onsite damage. On the other hand, downstream flooding is primarily a function of stormflow volume from headwater basins. Should stormflow volume for major runoff events be increased on many subwatersheds of a large basin, stormflow volume might be sufficiently increased on the parent watershed to cause downstream flooding. This downstream increase in stormflow would depend on the size of the increases from subwatersheds, the proportion of the parent watershed which exhibits increased stormflow, and the travel time of water from the various subwatersheds to the point of potential flooding. Only increases in stormflow of major runoff events are instrumental in downstream flooding; increases during frequent and minor runoff events are of little consequence.

An attempt has been made to isolate the effects of roads on storm runoff from other timber harvesting activities in several small watersheds. Changes have generally been minor, inconsistent, and in most cases, statistically nonsignificant at the 95-percent level of probability. Statistical nonsignificance has been due in part to the small number of runoff events suitable for inclusion in the analysis and to the high degree of variation in both pretreatment and posttreatment periods. Watershed studies have generally followed the same sequence. First, after watersheds were calibrated for 6 to 10 years, roads were constructed on certain watersheds, and their effect on streamflow was evaluated for 1 to 3 years. Then timber was harvested and the effects of its removal evaluated for several years. The calibration periods, because they have been longer, have had the greatest probability of containing large runoff events, those with a return period of 5 years or more. On the other hand, effects of roadbuilding can be evaluated for only 3 years; after 3 years the areas are altered by logging. Thus, there is generally a shortage of runoff events with which to evaluate the effect of roads alone. Where a sufficient number of events has been available, these events have been small with return periods less than that of the mean annual runoff event.

There has been much the same type of difficulty in assessing changes in storm runoff after timber harvest. The effects of logging and burning should be greatest the first winter after harvest. As the watershed is revegetated, the effects of these activities are ameliorated so that the condition of the watershed is somewhat improved. Consequently, the period of time a watershed is in a clearcut or burned condition is rather short, and the number of storm runoff events suitable for analysis again is generally small. Also, the size of these suitable events tends to be small.

Peak Flows

In the Alsea study in the Coast Ranges, the effects of roads alone on peak flow were variable. A significant increase in peak flow was noted only on a 40-ha watershed (AL-33) where roads occupied 12 percent of total watershed area (Harr et al. 1975). Here average peak flow was increased 0.055 $m^3/s \cdot km^2$ (5 csm) in both fall and winter. Both increases were highly significant. No significant increase in average peak flow after roadbuilding was noted in either the H. J. Andrews study or the Fox Creek study where roads occupied 8 percent and less than 2 percent of the respective watershed areas. In fact, in the H. J. Andrews study, a slight unexplained decrease in peak flow was noted after roadbuilding. At Coyote Creek, an increase in average peak flow occurred on a watershed (CC-1) in which roads and skid trails occupied about 15 percent of the watershed. In all four of the above cases, the runoff events used in analyses were generally less than 0.33 $m^3/s \cdot km^2$ (30 csm), and were of little consequence in potential damage to stream channels or hydraulic structures. Thus, for western Oregon, analyses of changes in peak flows have failed to reveal any consistent increase caused by roads alone.

There are only two instances where watersheds were clearcut (or nearly so) in the absence of logging roads. In the H. J. Andrews study, average peak flow increased 30 percent after a 96-ha watershed (HJA-1) was clearcut (Rothacher 1973). Some fall peaks were increased 200 percent, but again these peaks were very small and of little consequence in onsite damage. Similarly, in the Alsea study, average peak flow was increased 30 percent and average fall peak flow was increased 122 percent after a 16-ha watershed (AL-34) was 90 percent clearcut (Harr et al. 1975). Largest peak flows, i.e., greater than 1.1 $m^3/s \cdot km^2$ (100 csm) with return periods in excess of 5 years (fig. 7), were not significantly increased in the H. J. Andrews study (Rothacher 1973). In fact, two peak flows with return periods estimated to be in excess of 50 years were slightly less than predicted, well within normal variation observed during the calibration period (Rothacher 1971).

Timber removal combined with forest roads or extensive areas of soil compacted by other means has had the same effect on average peak flows as described for timber removal alone. Largest percentage increases were noted in the fall when maximum differences in soil moisture storage exist between cut and uncut watersheds. In the Alsea study, statistically significant increases were also observed in the winter on two watersheds (AL-33 and AL-1) 65 and 82 percent clearcut with 12 and 5 percent of their respective areas occupied by roads (Harr et al. 1975). Runoff events used in these analyses, however, averaged from 0.28 to 0.33 $m^3/s \cdot km^2$ (25 to 30 csm), much smaller than the annual runoff event estimated by flood frequency analysis (fig. 8).

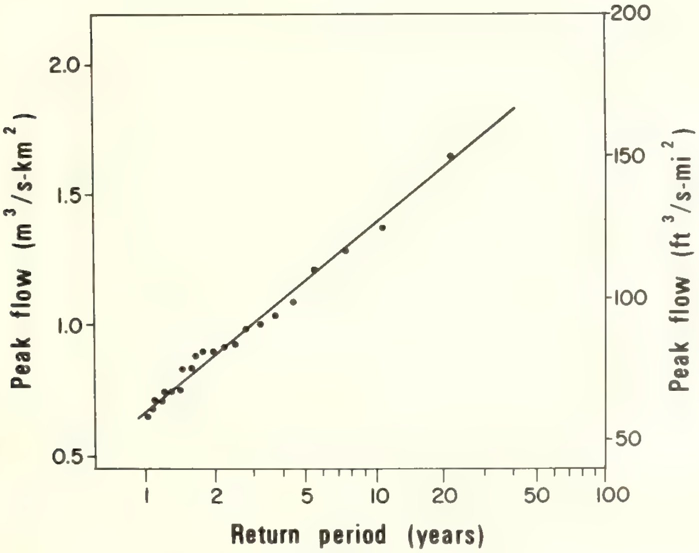

Figure 7.--Peak flow frequency analysis for the control watershed, H. J. Andrews Experimental Forest, 1952-73.

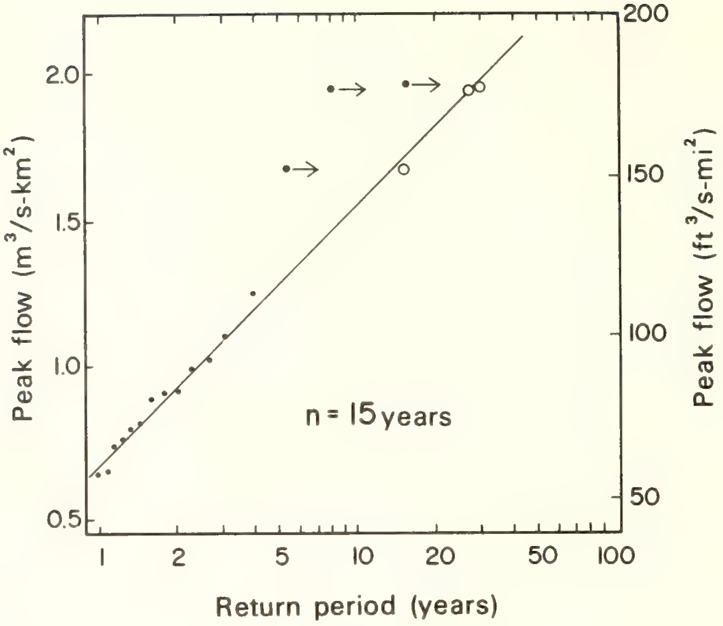

Figure 8.--Peak flow frequency analysis for control watershed, Alsea watershed study, 1958-73. The return periods of the three largest events were arbitrarily increased to be consistent with return periods of simultaneous peak flows on nearby streams of longer record.

In the watershed (AL-1) where only 5 percent of the area was occupied by logging roads and skid trails, no significant increase in peak flows above 0.55 $m^3/s\cdot km^2$ (50 csm) was observed (Harris 1973). In another watershed (AL-33) of this study where roads occupied 12 percent of total watershed area, the increase in peak flow appeared to exist for even the larger runoff events. Similarly, in the Coyote Creek study, where compacted soil from logging roads and tractor windrowing of slash occupied 13 percent of a watershed (CC-3) that was clearcut, the predicted increase in a peak flow of 1.1 $m^3/s\cdot km^2$ (100 csm) was 25 percent. Where compacted area occupied 15 percent of a watershed (CC-1) in which 30 percent of the forest was removed in a shelterwood cut, the predicted increase in a peak flow of 1.1 $m^3/s\cdot km^2$ (100 csm) was 27 percent.

Thus, the amount of a watershed in forest roads and skid trails appears to increase the size of larger peak flows as well as the smaller peak flows during the rainy season. This contrasts with clearcutting alone which appears to have little effect on larger peak flows. The reason for this increase is unclear but may be related to the location of disturbed soil relative to cut areas and watercourses.

Stormflow Volume

Changes in stormflow volume after roadbuilding and timber harvesting have been analyzed for only a small number of watersheds (Harr et al. 1975). In the Alsea study, changes after roadbuilding were variable. Some changes were large, but only increases in fall on the 90-percent-clearcut watershed were statistically significant. Once again, only small runoff events were available for these analyses.

Analysis of changes in stormflow volume after timber harvesting has not been completed in the U.S. Forest Service studies.

Discussion

The foregoing summary of results from watershed studies indicates the magnitude of changes in some aspects of streamflow after certain forest management practices are carried out. It is worthwhile to attempt to place these changes in perspective and see how they might apply to forest management in western Oregon.

An important question about increases in water yield involves regional forest management or management of watersheds many times larger than the headwater basins where water yield increases have been observed. In projecting experimental findings to large watersheds, Rothacher (1970) estimated that a 46-cm onsite increase would be equivalent to about a 2-cm increase on a large area patch-cut on a 100-year rotation. The trend in management, however, appears to be toward shorter rotation. Still, under even a 50-year rotation, timber on only about 2 percent of a large watershed would be harvested each year. With an initial increase of 46 cm and a logarithmic decline in annual increases (as Kovner (1957) and Ziemer (1964) have suggested) over a 20-year period, yield increases for clearcut areas would average about 10 cm per year. This is equivalent to 40 percent of a large basin showing a 10-cm increase (20 years ÷ 50-year rotation = 40 percent). But for 30 years of the rotation or on 60 percent of the large watershed, increases would be insignificant. Thus, for the total large drainage under sustained yield forest management, the annual increase would be about 4 cm. As Rothacher (1970) points out, excellent streamflow records should have an error of less than 5 percent which, for an annual flow of 100 cm, amounts to ± 5 cm. Because many large basins in western Oregon yield much more than 100 cm, the 4-cm increase discussed above will be difficult to detect in a large watershed even though large increases are known to occur in small headwater basins where 25- to 35-percent increases in annual yield have been observed. Of course, still shorter rotations and longer recovery times for cutover areas would increase annual yield from a large basin slightly more than that described above.

Results of watershed studies in western Oregon show storm runoff from small watersheds in headwater areas can be increased by soil disturbance and timber harvesting. These increases might have implications for channel erosion and design of hydraulic structures in these headwater areas and for downstream flooding.

Generally, attempts are made to design culverts and bridges to withstand at least the 25-year peak flow in western Oregon. If this size peak can be estimated reasonably and is indeed designed for, culverts and bridges are not likely to be damaged by an increase in storm runoff resulting from timber harvest alone.

Average peak flows can be increased, but the peaks to which these increases apply correspond to only 0.33 to 0.55 $m^3/s \cdot km^2$ (30 to 50 csm), well below the estimated 25-year peak of about 1.7 to 1.9 $m^3/s \cdot km^2$ (150 to 175 csm) (see Figs. 7 and 8). Analyses of larger runoff events (Harris 1973, Rothacher 1973) suggest that the effect of clearcutting decreases with increasing magnitude of the runoff event.

Design implications, potential onsite damage, and damage to hydraulic structures resulting from the effects of roads and other severely compacted areas on peak flows are much more serious than those of clearcutting. Roads are more permanent than clearcuttings and, unlike the situation with clearcutting, differences between watersheds with roads and watersheds without roads appear to exist even for large runoff events. In western Oregon, four experimental watersheds had at least 12 percent of their areas in roads, skid trails, and other areas of heavily compacted soil. For three of these watersheds, regression analyses indicate marked increases in peak flows with estimated return intervals of 3 to 5 years--peak flows larger than the mean annual runoff event. Using data from the Alsea watershed study, Harr et al. (1975) suggested that a 10-year runoff event might be increased to a 25-year event, and a 25-year event might be increased to a 90-year event on a watershed with 12 percent of its area in roads.

It is doubtful that normal clearcutting practices in the headwater areas of western Oregon have any appreciable effect on downstream flooding. Similar conclusions were reached for forested watersheds of the Eastern United States (Lull and Reinhart 1972, Hornbeck 1973). Such flooding results from extremely large, low-frequency runoff events. These are termed wet-mantle floods and are caused by such great amounts of precipitation that differences in soil moisture and interception between cut and uncut areas become insignificant. If a cable yarding system is used, soil disturbance is light (Dyrness 1967) and infiltration capacity largely unchanged on the clearcut area; cut and uncut areas should respond nearly the same during large storms. In addition, whatever differences do exist between cut and uncut areas are further masked downstream by water flowing from uncut areas. To illustrate this point, Harr et al. (1975) assumed a 100-year rotation, an initial increase in stormflow of 10 percent, and that increases in stormflow would not disappear until 20 years after timber harvest. They estimated that the maximum increase in total storm flow at the outlet of a typical large drainage in western Oregon would be about 1 percent; for a 50-year rotation, the increase would be about 2 percent, hardly enough to cause downstream flooding.

The effects of clearcutting on storm runoff also may be overshadowed by other hydrologic phenomena sometimes related indirectly to timber harvest. Road failures, natural slope failures, natural organic debris, and logging debris can temporarily dam streams and cause extreme peak flows when such dams eventually fail and release large quantities of water and debris. Culverts and bridges adequate to accommodate design flows have failed when plugged with debris (Rothacher and Glazebrook 1968). In addition, snow accumulation and melt rate in the ephemeral snow zone may be altered by clearcutting.

A potential application of results of watershed studies in western Oregon involves the relationship between increases in water yield and in peak flow. National Forests in the northern Rocky Mountains, for example, are regulating timber harvesting activities to minimize channel erosion (USDA Forest Service 1971, Table 3--*Summary of increases in annual yield, average peak flow, and large peak flows in experimental watersheds in western Oregon*

Location and watershed	Code	Area	Cut	Severely compacted[1]	Did increase occur?		
					Annual yield[2]	Average peak flow[2]	Large peak flow
		ha	*Percent*	*Percent*			
Alsea (Needle Branch)	AL-1	71	82	5	Yes	Yes	No
Alsea (Deer Creek)	AL-3	303	25	4	Yes	No	No
Alsea (Deer Creek #2)[3]	AL-32	56	30	3	Yes[4]	No	No
Alsea (Deer Creek #3)[3]	AL-33	40	65	12	Yes[4]	Yes	Yes
Alsea (Deer Creek #4)[3]	AL-34	16	90	0	Yes[4]	Yes	No
H. J. Andrews	HJA-1	96	100	0	Yes	Yes	No
H. J. Andrews	HJA-3	101	30	8	Yes	Yes	No
Fox Creek	FC-1	59	25	2	No	Yes	No
Fox Creek	FC-3	71	25	0	No	No	No
Coyote Creek	CC-1	69	30	15	No	Yes	Yes
Coyote Creek	CC-2	68	30	7	Yes	No	No
Coyote Creek	CC-3	50	100	13	Yes	Yes	Yes

[1] Figures here are not directly comparable. Some are for roads and skid trails only; others also include cut-banks and fill-slopes.

[2] Statistically significant increases ($\alpha=0.05$) in annual yield and average peak flows are indicated.

[3] The Deer Creek watershed was divided into subwatersheds.

[4] Annual yield data are not available, but increases are assumed, based on results of water yield analyses on other Alsea watersheds.

Delk 1972, Galbraith 1973) because increases in peak flow (and thus channel erosion) supposedly are related directly to increases in annual water yield.

However, in western Oregon there is no consistent relationship between increases in water yield and increases in peak flow after timber harvesting activities. Type of watershed treatment and whether or not increases occurred in annual yield, average peak flows, and large peak flows are shown in table 3. As can be seen, every possible combination of increases has been observed. Six experimental watersheds exhibited increases in annual yield and average peak flows. (Increases in water yield have been assumed for the three Deer Creek subwatersheds although annual yield data are not available.) Three watersheds showed an increase in water yield but none in average peak flow, and two showed no increase in yield, but an increase in average peak flow. The only consistency here is that all watersheds that were at least 65 percent clearcut showed increases in both water yield and average peak flows.

In terms of damage to stream channels by increases in peak flows, it seems improbable that these average peaks are very effective. Sediment concentrations are frequently high during initial fall runoff events, nearly all of which are smaller than the average peak flow; but this sediment most likely is soil that fell into the stream channel during the summer. Thus, even if a strong relationship did exist between increases in water yield and increases in average peak flow (it doesn't) it would be of little consequence in channel erosion.

Of considerably more importance to channel erosion are increases in larger peak flows, i.e., peaks with return intervals in excess of that of the mean annual peak (2.33 years). Peaks of this size appeared to have increased on only three experimental watersheds in western Oregon. Each of these watersheds had at least 12 percent of its area occupied by heavily compacted soil, mainly as a result of logging roads, tractor skidding, and tractor windrowing of slash. Thus, soil disturbance and its location relative to stream channels appear to offer a basis for developing a method for regulating timber harvesting to minimize channel erosion. However, the dynamics of channel erosion and sediment transport are insufficiently understood at this point to allow assessment of the effects of timber harvest activities on this type of erosion.

Summary

Results of four studies show certain aspects of stream flow in small watersheds in headwater areas in western Oregon were changed by roadbuilding, clearcutting, and other timber harvesting activities. Annual yields and summer low flows were increased significantly after clearcutting. Such increases, however, have only onsite importance, because under sustained yield forest management, increases in water yield from clearcut areas are greatly overshadowed by water flowing from uncut areas. Thus, yield increases in a large basin are extremely small. Both roadbuilding and clearcutting increased small peak flows. Large peak flows appeared to be increased where at least 12 percent of a watershed was seriously compacted by roadbuilding, tractor skidding, or tractor windrowing of slash.

Timber harvesting practices that do not severely modify soil properties on more than about 5 percent of headwater basins in western Oregon probably do not have any appreciable effect on large, low-frequency runoff events which cause extensive downstream flooding. These large events are wet-mantle floods caused by such great amounts of precipitation that differences in soil moisture content and interception between cut and uncut areas become insignificant. Thus, cut and uncut areas should respond nearly the same during these events. Moreover, differences that do exist are further masked by water flowing from uncut areas. In addition, slight effects of clearcutting on storm runoff may be overshadowed by the occurrence of other hydrologic phenomena that may be indirectly related to clearcutting. For example, large organic debris may plug culverts and cause them to fail during major runoff events, even though the culverts are adequate to carry the water produced (Rothacher and Glazebrook 1968).

The supposed relationship between increases in annual yield and increases in peak flow currently serving as the basis for regulating timber harvest in the northern Rocky Mountains (USDA Forest Service 1971, Delk 1972, Galbraith 1973) does not exist for western Oregon.

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RECREATION AND SCENIC RESOURCES IN ALASKA:

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An Annotated Bibliography

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PORTLAND, OREGON

Abstract

This bibliography provides descriptions of material published on recreation and scenic resources in Alaska. Included are publications on research, and supporting material in the form of studies and reports, proposals, plans, historical and cultural references, bibliographic documents, and popular books and articles describing the resources of Alaska and issues relating to their management and use. It contains author and keyword indexes.

KEYWORDS: Recreation (Alaska), resources (natural (conservation)), bibliography.

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USDA FOREST SERVICE General Technical Report PNW-50

RECREATION AND SCENIC RESOURCES IN ALASKA:

AN ANNOTATED BIBLIOGRAPHY

by

Robert M. Muth and Sally Anne Fitchet

1976

PACIFIC NORTHWEST FOREST AND RANGE
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Portland, Oregon

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INTRODUCTION

Alaska! Even the name evokes a sense of excitement and challenge. From the icefields of the Arctic to the bustling boomtowns of the pipeline, Alaska has a youthful vitality that beckons the adventurous, with its promise of riches, spiritual rejuvenation, the thrill of exploring the unknown and uncharted. To Alaskans as well as other Americans, the State is more than a sprawling land mass; it is a symbol, a new beginning, perhaps another chance at something we thought we'd lost. It's the last frontier, the outpost of the American pioneer dream of infinite resources, limitless freedom, and boundless hope for the future.

This abundance is not infinite, however. Alaska is not only our last frontier, it is our last chance--a final, unique opportunity to develop an effective resource management policy to insure that all this richness is used wisely. Such a policy would achieve a sensitive balance between resource development and protection of the scenic and recreational attractions of the Alaskan landscape.

Alaska's recreational and scenic resources are among her most valuable assets. The opportunity for most kinds of outdoor recreation is greater here than anywhere else in the United States. Tourism is among the four leading industries in the State, and outdoor recreation is an important part of the lives of most Alaska residents. As growth proceeds in Alaska, it is essential to plan for the conservation, protection, and rational development of these vast resources.

A fundamental requirement for the management of any natural resource is accurate information about its current and potential use. For many years the U.S. Forest Service has sought to expand its research program in Alaska to include recreation and scenic resources in order to provide information needed for truly comprehensive management planning. A necessary requirement for this research is easy access by scientists to existing research reports and other relevant literature. Scientists must be familiar with current research about a subject before they can add to it, and managers need easy reference to the latest knowledge as a basis for decisions. Bibliographies play a significant role in achieving these objectives.

This bibliography on recreation and scenic resources in Alaska seeks to fill this need with annotations on previous research-based documents on the subject and references to important related material.

The citations are organized under several categories.

PRIMARY INFORMATION

I. Research-based material, including published and unpublished studies, data-based reports, and journal articles on a variety of topics relating directly and indirectly to Alaska's recreational and scenic resources.

SUPPORTING INFORMATION

II. Management and planning material from local, State, and Federal agencies, private consulting firms, and individuals. For clarity and utility we have arranged this material as follows:

A. Studies, surveys, and reports
B. Proposals
C. Plans and programs
D. Policy documents

III. Historical and cultural material from books, pamphlets, and articles of historical or cultural significance.

IV. Bibliographic material, including bibliographies, indexes, and book catalogs.

V. Popular material including books, articles, and pamphets on travel and environmental issues, and material describing Alaska's recreation and scenic resources for the general public.

The sections are organized generically rather than topically. Publications on tourism, for example, may appear in the research section, the management and planning section, and so on, depending on whether the publication is a research study, a proposal for increasing tourism, etc. The keyword index provides an index by topic. If the reader wants to examine all the references relating to tourism, the keyword index provides a comprehensive list of citations relating to that topic regardless of type of publication.

We have annotated nearly all of the research-based documents. Many of the references in the other sections also have abstracts. The citations are numbered consecutively throughout the bibliography but are presented alphabetically by author within each section. The two indexes should increase the bibliography's utility:

1. The keyword index, mentioned above, allows readers to locate all materials on a specific topic by referring directly to the references corresponding to the numbers following each keyword in the index.

2. The author index alphabetically lists all senior and junior authors.

Copies of most of the materials included in this bibliography have been placed in the Forest Resources Library at the University of Washington.

We have attempted to cite all available research-based material on recreation and scenic resources in Alaska. The overwhelming impression of this effort is that little research-based information exists--and that much of what does exist is outdated. Most of the material is dated prior to 1974, although a few more recent sources are included. We encourage our readers to inform us of oversights and omissions, and to bring to our attention additional material they feel should be included in updated versions. We hope this bibliography will prove useful to researchers, resource managers, educators, students, planners, public officials, and business leaders concerned with the future of Alaska's recreational and scenic resources.

ACKNOWLEDGMENTS

We appreciate the assistance of Ron Yarnell in identifying, locating, and abstracting many references. Glen Uno and Paul Carroll provided additional assistance at different stages in the completion of this bibliography.

PRIMARY INFORMATION

I. Research-based Material

1. Alaska Department of Economic Development and Planning. 1962. Alaska passenger traffic survey, 1961. 17 p. Alaska Dep. Econ. Dev. and Plann., Juneau.

Increases in auto, railroad, and steamship travel to and from Alaska and a decline in air travel were reported in 1961. Total passenger movement in 1961 was 377,114, down from 1960. Statistics emphasize the importance of air travel to the total travel picture. The 1961 travel pattern is similar to that of the 1950's. July is the most popular month, and February the least popular, in which to travel. Distribution and seasonality of passenger traffic are discussed. Tables and indepth discussions of various modes of travel are included.

KEYWORDS: Use statistics, use projections, access, highways and roads, research.

2. Alaska Department of Fish and Game, Sport Fish Division. 1960. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, 1959-1960 Dingell-Johnson project report, 1:108-141, illus. Juneau.

The Alaska Department of Fish and Game became a primary agency in assuring anglers access to recreational fishing waters upon Alaska's entry into the Union. The investigation reviewed the activities of a number of other agencies and then incorporated their findings into their report. They studied certain waters to assess potential angler use and to determine means of site acquisition. Five basic criteria were involved in evaluating future potential. The study also reviewed the steps used in establishing the status of proposed public fishing access, sites, and the State and Federal laws pertinent to the acquisition of these sites, and evaluated 763 lakes and streams for access needs. One-hundred and twenty-three sites were requested and are being acquired under the various acquisition methods. Location, acreage, and front footage for the sites are located on maps.

KEYWORDS: Hunting and fishing, sites and facilities, use statistics, access, research.

3. Alaska Department of Fish and Game, Sport Fish Division. 1961. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, 1960-1961 Dingell-Johnson project report, 2:265-288, illus. Juneau.

Evaluation of 822 lakes and streams for access needs resulted in selection, reservation, and processing of 53 areas encompassing 247.8 acres. The areas of effort were scattered throughout the State. The principal effort of the project centered on rights-of-way leading from existing and proposed roads to suitable recreational fishing areas. Of 53 angler access trails surveyed, 15 were plotted and processed with responsible agencies, 24 were held in abeyance pending further data, and 14 were abandoned when conditions required much action. An additional acquisition of three use-sites and the necessary rights-of-way were a result of negotiations with private individuals. Forty-seven sites were recommended for access acquisition, but processing was delayed until necessary land survey records became available. Location and descriptive data on processed sites are tabulated.

KEYWORDS: Hunting and fishing, sites and facilities, use statistics, access.

4. Alaska Department of Fish and Game, Sport Fish Division.
1962. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, 1961-1962 Dingell-Johnson project report, 3:135-174, illus. Juneau.

Information obtained from the investigation and evaluation of 420 lakes and streams for public access needs resulted in the recommendation and subsequent processing of 79 use-sites in 86 waters. Total acreage of sites was 2,409.82 Need for site acquisition on a given water was based on physical inventory, fishing and angler use data, and information collected in the field from such sources as anglers, lodge owners, local residents, and Eskimo councils. A proposal is submitted recommending that a 10-foot public right-of-way be established on both banks of 48 valuable stream fisheries that pass through State lands. Locational data and other pertinent site information are tabulated and shown in map form.

KEYWORDS: Hunting and fishing, sites and facilities, use statistics, access.

5. Alaska Department of Fish and Game, Sport Fish Division.
1963. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, 1962-1963 Dingell-Johnson project report, 4:327-390. Juneau.

Evaluation of 1,289 waters for access requirements resulted in recommendations for selection, reservation, and processing of 150 sites encompassing 2,009 acres. The study surveyed 22 rights-of-way comprising 964,848 feet and initiated a new access water status file system--now in effect and covering more than 1,200 waters. There is a description of this system in the text, as well as a sample case history in the appendix.

KEYWORDS: Hunting and fishing, sites and facilities, use statistics, access.

6. Alaska Division of Lands.
1965. Alaska campers, 1964. 26 p. Alaska Div. Lands, Juneau.

Researchers gathered data from 28 campgrounds; they interviewed 1,219 individuals representing 4,884 campground uses. The study focuses on types of people using campgrounds, camping habits, campground activities, campers' opinions of campgrounds, and campers' willingness to pay. Findings include: The typical resident camper is between 20 and 44 years old, travels by car or camper, is married, has two children, lives in Anchorage or Fairbanks, and is most likely "military." The typical nonresident camper is between 45 and 64, travels by camper, and has his wife with him. Nonresident campers account for 33 percent of campground use. The study makes several recommendations for improving camping facilities to meet the desires of the camping population: create developed camping facilities within 100 miles of large centers of population, place more emphasis on picnicking facilities, and provide primitive facilities for hunters and fishermen. Tables are included.

KEYWORDS: Use statistics, sites and facilities, access, camping, research.

7. Alaska Division of Lands, Branch of Parks and Recreation.
1967. Alaska resident recreation demand survey. 24 p. Alaska Div. Lands, Branch Parks and Recreation, Anchorage.

The survey includes analyses of: (1) the favorite seasonal activities of residents, (2) activities residents do not engage in and the reasons they don't, (3) a recreation travel profile, (4) modes of recreational travel, and (5) the number of residents who engage in each recreational activity.

KEYWORDS: Use statistics, research.

8. Alaska Resource Development Board.
1956. Alaska passenger traffic survey, 1955. 13 p., illus. Alaska Resour. Dev. Board, Juneau.

The total passenger movement (entering and leaving Alaska) for 1955 was 245,590, down from the 1954 high of 256,027. The relationship of arrivals to Alaska to departures from Alaska changed dramatically in 1954: Arrivals outnumbered departures in 1953 by about 5,000; in 1954, departures outnumbered arrivals by almost the same amount. In 1955 the peak travel month was August, and February was the least-traveled month. Airlines carried 62 percent of the traffic, highways 29.4 percent, and steamships 8.3 percent. Water transportation decreased from 1950, air transportation increased, and highway traffic remained fairly constant. The survey goes into detail on use trends for these three modes of passenger transportation and illustrates these trends with bar charts.

KEYWORDS: Use statistics, highways and roads, access, research.

9. Arthur D. Little, Inc.
1963. A survey of potential interest in tourist travel to Alaska. 36 p. Alaska Dep. Econ. Dev. and Plann., Juneau.

KEYWORDS: Use projections, tourism, economic development.

10. Atamian, Sarkis.
1966. The fish and game violator. Univ. Alaska Inst. Bus., Econ. and Gov. Res., Res. Monogr. 7, 59 p. College [Fairbanks].

Pages 1-8 deal with outdoor recreation.

KEYWORDS: Hunting and fishing, use statistics, laws and regulations, research.

11. Barney, Richard J., and Erwin R. Berglund.
1974. Wildfire smoke conditions: interior Alaska. U.S. Dep. Agric. For. Serv., Res. Pap. PNW-178, 18 p., illus. U.S. Dep. Agric. For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Records of 21 stations were analyzed for the occurrence, persistence, and related visibility resulting from summertime wildfire smoke and haze in interior Alaska. Maximum probability of smoke occurrence for any station and month was 8.7 percent in July for Bettles. Seasonal occurrence of smoke was greatest for Tanana--3 percent. Persistence of smoke and reduction in visibility were not found to the extent previously assumed.

KEYWORDS: Fire and fire control, research.

12. Battelle Memorial Institute.
    1961. Report on an integrated transport system to encourage economic development of northwest North America. 425 p. Battelle Mem. Inst., Columbus, Ohio.

This report contains a section on tourism (p. 243-268) which includes analyses of Alaska travel, Alaska visitors, major areas of attraction to visitors, conditions affecting tourism, present and prospective use of Alaska's tourist recreation resources, potential increases in visitors to Alaska, and the possible effect of these potential increases on Alaska's economy. It emphasizes the unique nascent quality of the State's tourist and recreation industry and the value of Alaska's unspoiled wilderness,and warns of the consequences of a successful tourist promotional effort that might come before Alaska is prepared for it. Great distances, lack of facilities, physical hazards, highly fluctuating demand accompanied by seasonality, limited investment funds, poor service, high costs, and lack of an adequate financial promotional effort could hinder an Alaskan tourist development program.

The study predicts a possible fourfold increase in tourism in Alaska by 1980.

KEYWORDS: Use statistics, use projections, tourism, economic development, access, wilderness values, planning.

13. Bergstrand, Jay [L.]
    1970. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1969-1970, Federal Aid in Fish Restoration Project F-9-2: Sport Fish Investigations in Alaska, 11;331-342. Juneau.

KEYWORDS: Hunting and fishing, sites and facilities, access, use statistics.

14. Bergstrand, Jay L.
    1967. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1966-1967, Federal Aid in Fish Restoration Project F-5-R-8: Sport Fish Investigations of Alaska, 6:265-271. Juneau.

Statewide public access investigations were concerned largely with the broader aspects of multiple-use management rather than individual site recommendations. Public recreation land classification issued by the Department of Natural Resources, Division of Lands, reserved 82,298 acres in 138 lakes and 7 streams. Cooperative studies were conducted with the Bureau of Land Management to determine the highest possible utilization of the fish and game resources in proposed multiple-use area classifications located in certain areas. The study investigated fish size and distribution in 38 lakes, processed recreation and public purpose applications through BLM for three sites located on the Alaska peninsula and one site near Glenallen. Grants of rights-of-way obtained from private landowners will furnish access to two lakes and one river.

KEYWORDS: Hunting and fishing, use statistics, sites and facilities, use projections, access.

15. Bergstrand, Jay L.
1968. Investigations of public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1967-1968, Federal Aid in Fish Restoration Project, F-5-R-9: Sport Fish Investigations of Alaska, 9:323-337. Juneau.

KEYWORDS: Hunting and fishing, use statistics, sites and facilities, access.

16. Bergstrand, Jay [L.], and Thomas Nagata.
1969. Investigations of public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1968-1969, Federal Aid in Fish Restoration Project F-9-1: Sport Fish Investigations of Alaska, 10:369-383. Juneau.

KEYWORDS: Hunting and fishing, sites and facilities, access, use statistics.

17. Bergstrand, Jay L., and Edward J. Cramer.
1966. Investigations of Alaska's public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1965-1966, Federal Aid in Fish Restoration Project F-5-R-7: Sport Fish Investigations of Alaska, 7:249-296. Juneau.

KEYWORDS: Hunting and fishing, use statistics, access, sites and facilities.

18. Clawson, Marion.
1958. Statistics on outdoor recreation. 165 p. Resour. Future, Inc., Washington, D.C.

This publication contains statistics on recreational use of National Forests, National Parks and Monuments, and National Wildlife Refuges in the United States. Statistics on Alaska are included.

KEYWORDS: National Parks and Monuments, use statistics, use projections, National Forests, research.

19. Cramer, Edward J., and Jay [L.] Bergstrand.
1965. Investigations of public fishing access requirements. *In* Alaska Department of Fish and Game, Sport Fish Division, Annual report of progress, 1964-1965, Federal Aid in Fish Restoration Project F-5-R-6: Sport Fish Investigations in Alaska [Dingell-Johnson project report], 6:321-356. Juneau.

KEYWORDS: Hunting and fishing, sites and facilities, use statistics, access.

20. Elkins, W. A.
1952. Pressing problems in administration of wildlife resources in Alaska. *In* Science in Alaska, sel. pap. Natl. Sci. Conf., 1950, p. 268-281.

In 1952 there were three major human-related problems in administering the wildlife resources of Alaska. First, transients who began to swell Alaska's population after World War II harbored an exploitive rather than conservative attitude toward game, which increased hunting and fishing pressure around areas of settlement. Second, much of the Native population of Alaska depended on wildlife for its livelihood, making it difficult to enforce regulations designed to manage the wildlife resource according to the relatively lower demands of white sportsmen. Third, many commercial hunters and trappers believed that Alaska's wildlife resource was inexhaustible and that conservation was unnecessary.

KEYWORDS: Administration, fish and wildlife, hunting and fishing, management, laws and regulations, research.

21. Harris, Arland S., O. Keith Hutchison, William R. Meehan, and others.
1974. The forest ecosystem of southeast Alaska. 1. The setting. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW-12, 40 p., illus. U.S. Dep. Agric. For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

This is the first in a series of publications summarizing knowledge of southeast Alaska's forest resources, published to provide managers and users of these resources with the most complete information available to estimate the consequences of various management practices. This report describes the physical, biological, and socioeconomic setting of southeast Alaska (including geography, climate, vegetation types, geology, minerals, forest products, soils, fish, wildlife, water, recreation, and esthetic values) to provide a background for the more technical reports which follow. A bibliography is included.

KEYWORDS: Fish and wildlife, flora, geology, lakes and waterways, National Forests, Wilderness and Primitive Areas, wilderness values, management, scenery, research.

22. Harrison, Gordon S.
1975. The people and the parks: reactions to a system of public transportation in Mt. McKinley National Park, Alaska. J. Leisure Res. 7(1):6-15.

In 1972 the National Park Service greatly restricted the use of private automobiles in Mount McKinley National Park, Alaska. As a substitute for private transportation, the Park Service offered free bus service for visitors. Also for the first time in 1972, the Park Service required that visitors have advance reservations for campsites in the five campgrounds located well inside the Park.

To evaluate the impact of these new regulations, the Park Service contracted with the Institute of Social, Economic and Government Research of the University of Alaska to conduct a study of public reaction to the regulations. Opinions of Park visitors were surveyed during the summer months of 1972 (phase I), and the opinions of Alaska residents were surveyed during the winter of 1973 (phase II).

Phase I of the study revealed that the vast majority of people who visited the park approved of the new transportation policy. Phase II of the study indicated that 55 percent of the 459 individuals returning questionnaires after the first mailing who knew about the new transportation policy approved it; 35 percent disapproved. However, of the much smaller number of informed people who returned questionnaires after the second mailing (37 total) 44 percent approved and 49 percent disapproved, which suggests that the resident population of Alaskans in Anchorage and Fairbanks may divide nearly 50-50 on their opinion of the new policy.

KEYWORDS: National Parks and Monuments, access, highways and roads, research.

23. Helmers, Austin E., and Charles T. Cushwa.
1973. Research opportunities and needs in the taiga of Alaska. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW-2, 14 p., illus. U.S. Dep. Agric. For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

Taiga (the northern forests of interior Alaska) research opportunities and needs can best be met through a multidisciplinary interagency program. The study suggests closer coordination among several departments of the University of Alaska and a number of State and Federal agencies currently involved in applicable research. Taiga environment information needs encompass five major problem areas: ecology, fire effects, water, culture, and economics.

KEYWORDS: Wilderness and Primitive Areas, research.

24. Hinkson, Charles E.
1964. Traveler profiles: a study of summer travel to Alaska during 1963 and 1964. [n.p.], illus. Alaska Dep. Econ. Dev. and Plann., Juneau.

This report presents data on movement and characteristics of people traveling in Alaska during the summers of 1963 and 1964. Two types of travelers are examined: the visitor (traveling primarily for reasons other than pleasure) and the vacationer. The study analyzes modes of travel, origin, destination, expenditures, length of stay, party size and composition, and opinions of travelers. Over one-half of the 1964 summer travelers in Alaska were tourists ("vacationers"), one-third were Alaskans; and one-tenth were nonresident businessmen. For 85 percent of the vacationers, it was their first visit to the State. Seventy-five percent lived west of the Mississippi, and 25 percent were from the Great Lakes region. Expenditures in Alaska by vacationers depended on their mode of travel and averaged $454. Vacationers traveled in parties averaging 2.7 people and stayed in Alaska an average of 10 days. Travelers reported that the greatest single appeal of Alaska is its "scenic beauty."

KEYWORDS: Tourism, use statistics, access, research.

25. Hok, Jerome R.
1969. A reconnaissance of tractor trails and related phenomena on the North Slope of Alaska. 68 p., illus. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

On the basis of one summer's reconnaissance, the author has provided both factual information and a primer for anyone interested in the tundra-permafrost environment of the North Slope of Alaska and much of the land surrounding the polar basin. The report emphasizes the long-lasting effects of the movement of vehicles across, or operations in, this environment. His illustrations show the importance and interrelationship of season, the degree of disturbance, and the moisture content and topography and their effects on erosion of the North Slope of Alaska. The report is illustrated extensively with evidentiary black and white photographs.

KEYWORDS: Highways and roads, research.

26. Kiely, Vernon R., and John M. Hilpert.
1961. Tourist industry in Alaska. 240 p., illus. Univ. Alaska, College [Fairbanks].

Suggestions made in this report for attracting more visitors to Alaska include more campsites, employment of Alaskans in tourist businesses, more restaurants serving food at moderate prices, better entertainment for tourists, and improved transportation to Alaska. Results of the survey conclude that 68 percent of Alaska's visitors were on vacation, more than half were male, average length of stay was 20 days, $17 per day per person was spent, and 47 percent of visitors stayed at campsites. The report also gives a detailed discussion and analysis of visitor facilities at several tourist areas in Alaska.

KEYWORDS: Tourism, sites and facilities, use statistics, planning, economic development.

27. Kiely, Vernon R., and John M. Hilpert.
1963. Alaska's tourist business. 4 p. Small Bus. Adm., Washington, D.C.

This booklet is an abridged version of the 1961 report (26).

KEYWORDS: Tourism, economic development.

28. McIlroy, Carl W.
1972. Effects of hunting on black bears in Prince William Sound. J. Wildl. Manage. 36(3):828-837.

Hunting pressure on the black bear population in the coastal regions of Alaska has been increasing steadily since the early 1960's, radiating from the immediate area of Valdez (Port Valdez and Valdez Arm) into more remote, previously unhunted, surrounding areas. This article presents study data relating area-specific changes in hunting pressure to changes in the black bear population and hunter success in most of these hunting regions. Harvest data were collected between 1966 and 1969. Approximations of abundance of bears in the area were based on the number of bears killed and the number known remaining in several small bay areas; changes in bear population were assessed by number, age, and sex. The total bear harvest in the region under examination increased between 1962 and 1966 and decreased between 1966 and 1969, although the number of hunters continued to increase during both periods. The author assesses factors affecting vulnerability of bears to hunting: environment, hunting techniques, and the possibility of changing behavior of bears due to hunting pressure. He concludes that the large harvests of bears in the early 1960's and the resulting decreasing abundance of black bears account for the decline in hunter success at Port Valdez and Valdez Arm between 1966 and 1969. Maps illustrate the article; tables are included.

KEYWORDS: Fish and wildlife, hunting and fishing, research.

29. Meehan, William R.
1974. The forest ecosystem of southeast Alaska. 4. Wildlife habitats. U.S. Dep. Agric. For. Serv., Gen. Tech. Rep. PNW-16, 32 p., illus. U.S. Dep. Agric. For. Serv., Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

The report discusses the effects of logging and associated activities on the habitat of the major forest wildlife species in southeast Alaska and summarizes research results applicable to this region. The two main habitat requirements for wildlife are food and cover. Many of the wildlife species in southeast Alaska utilize mature, old-growth forests, generally for cover. Some of the fur bearers and the bald eagle use the beach fringe as the most important part of their territories. Black-tailed deer use the beach timber during severe winter periods. Mountain goats descend from their summer alpine habitat to timber during parts of the winter. Bears seasonally use the timber bordering tidal meadows, beaches, and streams for cover. In general, for maximum wildlife production, small patch cuts or clearcut strips with blocks or strips of timber left between them appear to be the ideal pattern. Timber along the beach and adjacent to grass flats should remain unlogged and of a sufficient width to maintain wintering herds, to provide escape cover and eagle nesting sites, and to alleviate the possibilities of blowdown. For the foreseeable future, the greatest problem in forest-wildlife relationships in southeast Alaska is correlation of timber cutting methods with wildlife production. These two resources must be managed together along with water, recreation, esthetics, and other forest-land uses. Detailed, specific recommendations are made for further research needs as a basis for wildlife management in southeast Alaska.

KEYWORDS: Fish and wildlife, research.

30. Murie, Olaus J.
1952. Planning for Alaska's big game. *In* Henry Collins (ed.), Science in Alaska, 1950, sel. pap. 1st Annu. Sci. Conf. Proc., p. 258-267. Alaska Div. Am. Assoc. Adv. Sci., Juneau.

Growth in populations of humans and wolves has resulted in a decrease in the number of moose, caribou, mountain sheep, and other big-game species. However, in some cases an increase that might be due to a natural "rotation" or population cycle follows a decrease. This might be the result of a wearing out of traditional forage areas and their subsequent regeneration after a decrease in their use. Management should base wildlife planning on zones, to insure that one species does not compete with another for food. Wildlife zones reserved for preservation of a game species could also be used for other activities, such as wilderness recreation. The State of Alaska must undertake extensive land-use planning to preserve its big-game resources, using the successes and failures of wildlife management planning in the continental United States as one of its guidelines. Wildlife management planning for Alaska must be multidisciplinary and based on sound ecological laws. The author stresses this principle throughout his article: "Wildlife planning for Alaska is part of a wider endeavor."

KEYWORDS: Wildlife refuges and ranges, fish and wildlife, wilderness values.

31. Murphy, R. S.
1970. Water quality requirements in Alaska campgrounds with projections of recreation demands and benefit/cost analysis for site selection. [n.p.] Univ. Alaska Sch. Eng., College [Fairbanks].

Alaska's outdoor recreation resources represent a major income-producing sector of the State. To a large extent Alaska's further growth appears restricted by insufficient and inadequate campgrounds. Existing camping facilities have not been examined thoroughly in terms of water quality problems, and the role of water in benefit/cost analysis in evaluating recreation in Alaska barely has been touched. The product of such a study would provide important information which would aid directly in the programing of new recreation sites.

KEYWORDS: Sites and facilities, economic analysis, camping, lakes and waterways.

32. Reeve, Stephen M.
1971. An ecological approach to land use planning on the Kenai Peninsula, Alaska. M.A. thesis, Univ. Alaska, Fairbanks. 53 p., illus.

Recent years have witnessed a great acceleration of demands on the Kenai Peninsula environment, resulting in numerous conflicts in land and resource utilization. On the peninsula, perhaps more than in any other region of Alaska, the forests, wildlife, water resources, recreation lands, tidelands, petroleum development, and urbanization constitute a set of interrelated problems. Current planning efforts fail to consider this systemic character of the region's resources, and little information exists describing the ecology or physical conditions that would allow judicious management of the Kenai Peninsula environs. A key objective in this paper is to set forth a methodology for planning the region's environment in a manner that treats individual physical and biotic resources as parts of a process that becomes the basis for land and resource use decisions. The study is illustrated with numerous full-color photographs and maps.

KEYWORDS: Research, Kenai Peninsula, land-use planning, planning, management.

33. Rich, Pamela E., and Arlon R. Tussing.
1973. The National Park System in Alaska: an economic impact study. 88 p., illus. Univ. Alaska Inst. Soc., Econ., and Gov. Res., College [Fairbanks].

This study evaluates the economic importance of the Park System to Alaska. Visitor expenditures and Federal outlays for the four areas (Mount McKinley, Glacier Bay, Katmai, and Sitka) are examined. Of the $45 million spent by tourists in Alaska in 1971, $29 million was spent visiting one or more of the National Parks or Monuments. This represents 64 percent of total tourist expenditures that year. The report discusses factors limiting economic contributions. Accessibility, patterns of expenditures, and the impact of expenditures and future projections are analyzed. Use patterns and investments in the park areas are described with photographs, maps, tables, and references.

KEYWORDS: Tourism, sites and facilities, use statistics, National Parks and Monuments, economic analysis.

34. Sommerville, Ronald J.
1967. Land evaluation. Alaska Div. Game, vol. 8, Annu. Proj. Segment Rep., Fed. Aid. Wildl. Restoration, Proj. W-5-C-8, Lands, 22 p. Juneau.

KEYWORDS: Land-use planning, land classification, hunting and fishing, fish and wildlife.

35. Stanton, William J.
1953. Analysis of Alaska travel. Vol. 2 of Part 1, economics, Alaska recreation survey. 127 p., illus. U.S. Dep. Inter. Natl. Park Serv.

This report is the second in the economic series of the Alaska recreation survey. The results and contents are similar to "Analysis of passenger travel to Alaska with special reference to tourism" (36). "It is essential to preserve the unique characteristic of the country which causes people to want to go there in the first place." The report focuses closely on the 1952 tourist season, with emphasis on an analysis of particular tourist groups, their interests, characteristics, and modes of travel.

KEYWORDS: Tourism, use statistics, sites and facilities, wilderness values, access.

36. Stanton, William J.
1953. Analysis of passenger travel to Alaska with special reference to tourism. 96 p., illus. Univ. Wash. Coll. Bus. Adm., Bur. Bus. Res., Seattle.

This analysis is one of the first successful efforts to measure visitor travel to Alaska. The report presents and analyzes the findings from a survey conducted during the summer of 1952. The author analyzes passenger travel in general and tourist travel specifically and discusses and summarizes the methods he used. Of 30,000 people who entered Alaska, 53 percent traveled by air, 19 percent by sea, and 28 percent by highway. Of the 65,000 people who departed from Alaska during the summer of 1952, 80 percent were nonresidents, 44 percent were from the Pacific coast of the United States, and 91 percent were making their first trip to Alaska. Dollar volume was over 6.3 million.

KEYWORDS: Highways and roads, access, tourism, use statistics.

37. Stanton, William J.
1953. Economic aspects of recreation in Alaska. Vol. 1 of Part 1, Alaska recreation survey. 191 p., illus. U.S. Dep. Inter. Natl. Park Serv.

This report is the first of a series resulting from the Alaska recreation survey. It documents the nature of the recreation resources of Alaska and indicates the economic importance of recreation to Alaska. It includes a field survey of human and natural resources, as well as an extensive study of the tourist industry, including an inventory of attractions, accommodations, and facilities. It is considered a pioneer report on the recreation economics of Alaska.

KEYWORDS: Tourism, sites and facilities, highways and roads, recreation inventories, economic development, economic analysis, National Parks and Monuments.

38. Steinhoff, Harold W.
1969. Values of wildlife and related recreation on the Kenai National Moose Range. 33 p. Univ. Alaska, Alaska Coop. Wildl. Res. Unit, College [Fairbanks].

KEYWORDS: Kenai Peninsula, economic analysis, research, wildlife refuges and ranges.

39. U.S. Outdoor Recreation Resources Review Commission.
1962. Alaska outdoor recreation potential. ORRRC Stud. Rep. 9, 63 p., illus. Gov. Print. Off., Washington, D.C.

The major task of the study was to summarize factors and points of view that had dominated public actions and to analyze changes in public action that appeared to be desirable, in the light of new knowledge and new conditions. The report contains a general description of the three major regions of Alaska, recreation resources surveys, and recreation potential, followed by data illustrating major economic, political, and technological changes that had affected recent recreational development in Alaska. Nine specific problem areas and recommended solutions are discussed: State recreation coordinators, separation of recreation functions at the State level, new regional office of the National Park Service, recreation on the public domain, fire control and the management of recreation potential, wildlife preservation, local recreation in Alaska, reservation of shorelines for public recreation, and climatic criteria for recreation planning.

KEYWORDS: Planning, management, land classification.

40. University of Alaska, Institute of Water Resources Research.
[n.d.] An investigation of the water recreation potential of the lakes and rivers of the upper Alaska peninsula, southwest Alaska. 15 p., illus. Univ. Alaska Inst. Water Resour. Res., College [Fairbanks].

KEYWORDS: Sites and facilities, hunting and fishing, boating, lakes and waterways, use projections, research.

41. Watt, [Richard] Darrell.
1964. Fairbanks residents and outdoor recreation in interior Alaska. *In* George Dahlgren (ed.), Science in Alaska, 1964. 15th Alaskan Sci. Conf. Proc., 11 p.

From a systematic sampling of 5 percent of the households in Fairbanks, each household expended an average of $196 and 12.5 days annually for outdoor recreation (hunting, fishing, skiing, boating, and camping). Newcomers to Alaska felt restricted in their outdoor recreation activities by the great expense of access to recreation areas, licenses, equipment, and some of the unfamiliar, unique features of the Alaskan landscape (distance, climate, etc.). The households felt the Fairbanks vicinity needed more overnight camping facilities and better access to lakes and streams; 26 percent thought the facilities available were the best in the United States (especially those who viewed isolation as a resource in itself); and 67.7 percent said that Alaska had greater outdoor recreation potential than any other State. Tables support the narrative portion of this report.

KEYWORDS: Use statistics.

42. Watt, Richard Darrell.
1966. The recreational potential of the Arctic National Wildlife Range. M.S. thesis, Univ. Alaska, Coll. Biol. Sci. and Renewable Resour., College [Fairbanks]. 103 p., illus.

Potential opportunities exist in the Arctic National Wildlife Range for activities such as hiking, backpacking, canoeing, mountain climbing, photography, hunting, and fishing. Returned questionnaires from hiking clubs revealed that 18 percent of respondents would be willing to spend about $200 per person to visit the Range from Fairbanks. It is estimated that tourism and recreation in the Range will not be a vital State economic force but that the Range is important as a symbol of Alaskan wilderness. The author makes some recommendations concerning land use and land-use planning on the Range.

KEYWORDS: Fish and wildlife, hunting and fishing, sites and facilities.

43. White, Gregory K., and Wayne C. Thomas.
1973. A method for establishing outdoor recreation project priorities in Alaska. 70 p., illus. Univ. Alaska Inst. Agric. Sci., Fairbanks.

The objectives of this study are to define public benefits of outdoor recreation and to develop a priority ranking method for proposed outdoor recreation projects. The study reviews various methods of analysis which have been used to estimate the value of recreational benefits. The proposed priority ranking method is based on a modification of benefit-cost analysis and is called the service-potential/cost ratio. It measures the potential ability of an outdoor recreation project to generate public benefits per dollar cost of the project. Although the problem of how to allocate resources between recreation and other sectors of the economy has not been solved, the study attempts to provide a method for allocating to projects recreational funds that will return to the public the greatest benefit flow per dollar of cost.

KEYWORDS: Planning, economic analysis, administration.

SUPPORTING INFORMATION

II. Management and Planning Material

A. Studies, Surveys, and Reports
B. Proposals
C. Plans and Programs
D. Policy Documents

A. STUDIES, SURVEYS, AND REPORTS

44. Advisory Committee on Land Use, and Subcommittees to the Alaska Planning Council.
1938. Land use in Alaska: A preliminary report. 97 p. Advis. Comm. Land Use, and Subcomm. Alaska Plann. Counc.

As an initial step in land-use planning, the committee has outlined the nature and scope of a preliminary land classification program for the Territory of Alaska. The Territory is divided for this purpose into six regions. In addition to this general land classification program, the committee has made a preliminary study of some problems relating to those specific types of public lands for which Federal or Territorial legislation has been enacted in the past, including school land, tidelands, escheated lands, homesteads, grazing lands, National Parks and Monuments, and Indian allotments. Coal, oil, and other mineral lands are not within the scope of the report.

KEYWORDS: Land-use planning land classification.

45. Alaska Department of Economic Development, Division of Economic Enterprise.
1975. A performance report of the Alaskan economy: 1974 year-end review of projections to 1980. Alaska Dep. Econ. Dev. Div. Econ. Enterp. 3(1):1-32, illus. Juneau.

Page 12 contains growth projections for the tourist industry through 1980. Pages 24-25 describe the current situation of the tourist industry. Growth of tourism in Alaska is expected to slow somewhat from 1974 to 1980 due to the general economic uncertainty in the U.S. Nonetheless it should sustain a rate of 10 percent, increasing the number of annual tourists to 425,000 during 1980. Airline and cruiseship travel is expected to increase in relation to highway travel. The historical annual average increase in tourist traffic to Alaska has been about 15 percent; the 1974 season had an estimated 11-percent increase. Resident tourism is up, probably due to "pipeline prosperity." Graphs are included.

KEYWORDS: Tourism, access, economic development, use statistics, use projections.

46. Alaska Department of Labor, Employment Security Division.
1974. Tourism: A growth industry. Alaska Econ. Trends (May 1974), 7 p.

Report includes statistics on tourist use trends and is illustrated with charts and graphs. Tables are included. The narrative presents an overview of the tourist situation in Alaska.

KEYWORDS: Tourism, use statistics, use projections, economic development.

47. Alaska Division of Lands.
1970. Alaska Division of Lands, 1970 annual report. 63 p., illus. Alaska Div. Lands, Juneau.

Major events that affected the State Park System during 1970 include passage by the legislature and subsequent approval by the voters of a $2.3 million bond issue for construction of outdoor recreation facilities. This, together with Federal matching funds, will provide approximately a $5 million program of development for the State Park System. The legislature established the first State park, increasing the acreage in the State Park System by 2,500 percent. The Parks and Recreation Section was elevated to Division status within the Alaska Department of Natural Resources. The master plan study for the Keystone Canyon State Park was completed, as was that for the Captain Cook Recreation Area. The establishment of the Denali State Park and the Chugach State Park brought the total acreage within the State Park System to nearly a million acres. Site plans were completed for the Salcha River Wayside and the South Rolly Lake Campground. The first 5 miles of road within the Nancy Lake Recreation Area were completed, as were the Clam Gulch Wayside and Harding Lake Recreation Areas. The report is illustrated with photographs, maps, charts, and tables.

KEYWORDS: State parks, administration, planning, sites and facilities.

48. Alaska Division of Parks.
1970. 1970 visitation to the Alaska State Park System. 6 p. Alaska Div. Parks, Anchorage.

KEYWORDS: Use statistics, State parks.

49. Alaska Division of Parks.
1971. Alaska outdoor recreation and historic preservation report: 1971. 117 p., illus. Alaska Div. Parks, Anchorage.

This report contains statistics on Alaska's recreation areas and visitation rates; revenue and expenditures of Federal, State, and local park agencies during the fiscal year; a summary of acquisitions and development projects; 5-year schedules of acquisition and development on Federal, State, and local levels; a list of projected surplus or deficits of space and facilities by 1975 under the categories: community recreation, space, outdoor game areas, picnic facilities, campgrounds, trails, swimming beaches, boat launching ramps, and float moorages. It also contains a review of historic preservation planning in Alaska, with future plans. Finally, a section is devoted to recreational and environmental accomplishments other than acquisiton and development: Plans for implementing recreation and environment programs, legislation, and other programs. Maps, charts, and tables comprise the bulk of the study.

KEYWORDS: Sites and facilities, use statistics, use projections, administration, management, State parks, planning.

50. Alaska Division of Parks.
1971. Alaska State Park System: visitation estimates, fiscal year 1972. 6 p., illus. Alaska Div. Parks, Anchorage.

KEYWORDS: Use statistics, State parks.

51. Alaska Division of Parks.
1972. Alaska outdoor recreation, historic preservation, 1972. 203 p., illus. Alaska Div. Parks, Anchorage.

KEYWORDS: State parks, sites and facilities, administration, management.

52. Alaska Division of Parks.
1973. Summary of visitation: 1973. 6 p. Alaska Div. Parks, Anchorage.

KEYWORDS: Use statistics, State parks.

53. Alaska Division of Parks.
[n.d.] Alaska outdoor recreation news. (Bi-monthly newsletter.) Varying pages, illus. Alaska Div. Parks, Anchorage.

KEYWORDS: Administration, sites and facilities, management.

54. Alaska Division of Parks, Office of Statewide Cultural Programs.
1974. Lower Copper and Chitina Rivers: an historic resource study. Hist. Archeol. Ser. No. 5, Misc. Publ., 46 p., illus.

The purpose of this study is to provide the Alaska Department of Highways with information on which to base decisions regarding preservation and management of cultural values within the rights-of-way for the Copper River Highway and the Chitina-McCarthy Road. The study includes a summary of the known prehistory and history of the area under investigation; an account of preservation actions taken to date in the region; an inventory of identified archeological and historical features, including some not within the rights-of-way for which the Department of Highways may wish to encourage preservation and interpretation by cooperator groups such as local historical societies and cultural organizations; and recommended preservation philosophy, on which are based proposals for recordation, salvage, preservation, and interpretation of significant features. The study does not include sites that might be used to interpret natural history. The report contains maps, photos, and a 4-page section of bibliographic references.

KEYWORDS: Historical and cultural heritage.

55. Alaska Division of Policy Development and Planning.
1975. Alaska tourism in the bush. 47 p. Alaska Div. Policy Dev. and Plann., Juneau.

KEYWORDS: Tourism.

56. Alaska Environmental Group.
1974. Hatcher Pass study area. 45 p., illus. Alaska Div. Parks, Anchorage.

The purpose of this study was to prepare a long-range master plan for future development of a recreation area encompassing the former mining area in the Talkeetna Mountains known as Hatcher Pass. The report provides a summary of the planning effort undertaken for the State to assist in deciding the ultimate development and use of the Hatcher Pass study area. The material is presented in three sections: an inventory of the natural and cultural environment of the study area; a summary of the recommended uses of its lands, waters, and other recreation resources; and guidelines for implementation of the recommended plan. The report is illustrated with full-color maps and black-and-white photos.

KEYWORDS: Planning, State parks, sites and facilities.

57. Alaska Outdoor Recreation Institute.
1968. Selected proceedings of the 18th annual conference, 1968. Alaska Outdoor Recreation Institute, vol. 3. 28 p. Alaska Munic. League, Juneau.

Five speakers discuss the contributions of the agencies they represent--the National Association of Counties, the U.S. Bureau of Outdoor Recreation, Cresap, McCormick and Paget (a private consulting firm), the National Recreation and Park Association, and the State of Alaska--to the overall development and maintenance of Alaska's recreation resources.

KEYWORDS: State parks, planning, management, administration.

58. Alaska Visitors Association, Inc.
1973. Alaska State Legislative Interim Committee on Tourism. 19 p., illus. Alaska Visitors Assoc., Inc., Anchorage. [November 29 and 30, 1973, Anchorage.]

KEYWORDS: Tourism.

59. Allen, Roger W.
1961. The need for recreation lands in Alaska. *In* George Dahlgren (ed.), Science in Alaska, 1961. 12th Alaskan Sci. Conf. Proc., p. 111-113.

Alaska's natural scenic beauty could make tourism the major force for economic progress in the State. Selection and classification of public lands for recreation should begin immediately.

KEYWORDS: Tourism, economic development.

60. Alman, R. K.
1967. Development plan report: Eagle Trail Wayside. 11 p. Alaska Div. Lands, Branch Parks and Recreation.

KEYWORDS: Planning, trails and hiking, sites and facilities.

61. Blum, Joseph R.
1968. Land evaluation. Alaska Dep. Fish and Game, vol. 9, Annu. Proj. Segment Rep., Fed. Aid Wildl. Restoration, Proj. W-5-C-9, Lands, 63 p. Juneau.

The objects of the project are to identify specific key game areas; to submit recommendations for the orderly selection, classification, or purchase of specific lands for public hunting access and use; and to assist in statewide land-use planning to assure consideration of fish and wildlife values. The report covers the period July 1, 1967, to June 30, 1968.

KEYWORDS: Land classification, land-use planning, hunting and fishing, fish wildlife, research.

62. Blum, Joseph R.
1970. Report of survey-inventory activities: land evaluation. Alaska Div. Game, vol. 10, Annu. Proj. Segment Rep., Fed. Aid Wildl. Restoration, Proj. W-5-C-1; W-17-2, 25 p. Juneau.

The report covers the period from July 1, 1968, to December 31, 1969. Statewide activities centered on land-use planning. The study team worked extensively with the U.S. Bureau of Land Management on their classification programs, as well as with the U.S. Forest Service and National Park Service. On the State level, most activities centered around development of oil, gas, and timber resources on State land.

KEYWORDS: Land classification, land-use planning, research.

63. Bowers, John F.
1958. The public recreation areas program in Alaska. *In* Science in Alaska. 9th Alaskan Sci. Conf. Proc., p. 52. [College [Fairbanks], Alaska.]

This report is a general summary of the current activities and accomplishments of public agencies involved in the planning, development, and maintenance of outdoor recreation programs in Alaska.

KEYWORDS: Administration, planning, management.

64. Bowman, Wallace.
1962. A plan for developing Alaska's recreation and tourist potential. *In* Science in Alaska, 1962. 13th Alaskan Sci. Conf. Proc., p. 56-68.

Alaska's recreational endowments must reflect human needs before they may be called resources. The author discusses the success and failure of recent development plans in light of this statement. The outcome of the publication of a 1962 Rockefeller Commission report on the subject was the formation of the Federal Bureau of Outdoor Recreation and the drafting of a Federal act which, if passed, would provide funds for a grant program. Still, the burden of development will be on the State, and the weakest link in the Alaska recreation development situation is the lack of organized and articulate groups supporting the concept of development and planning at the State level.

KEYWORDS: Tourism, State parks, planning.

65. Brent, Stephen M., and Robert M. Goldberg (eds.).
1970. Recreation. *In* Alaska survey and report: 1970-71, p. 421-430, illus. Res. Inst. Alaska, and Anchorage Daily News.

This section of the "Alaska Survey and Report" inventories the major species of Alaskan game and fish, suggests the best places to find them, and outlines regulations pertaining to hunting and fishing. Also included is a list of campgrounds and facilities in Alaska, prepared by the Alaska State Travel Division.

KEYWORDS: Recreation inventories, hunting and fishing, fish and wildlife, laws and regulations, sites and facilities.

66. Brent, Stephen M., and Robert M. Goldberg (eds.)
1970. Tourism. *In* Alaska survey and report: 1970-71, p. 189-193, illus. Res. Inst. Alaska, and Anchorage Daily News.

The tourist industry has greater potential for creating jobs for Alaskans than any other, including the oil industry. Lack of suitable accommodations at Mount McKinley National Park and the economic disadvantages of constructing large, high-quality tourist facilities for an annual season lasting only 4 months can be expected to hinder the growth of Alaskan tourism in the future. The Alaska Highway and the Marine Highway bear 60 percent of the total tourist traffic. Air traffic has increased at an annual rate of 16 percent in recent years. Charts and tables are included in this section.

KEYWORDS: Tourism, use statistics, economic development, access, use projections.

67. Cameron, John, Robert Marshall, and Paul W. Gordon.
1937. Recreational resources and facilities. *In* Regional planning, Part VII--Alaska, Its resources and development. p. 127-144, illus. Nat. Resour. Comm., Alaska Resour. Comm., Washington, D.C.

Utilization of Alaska's recreational resources by outsiders is limited because of financial, geographical, and climatological impediments to easy access and use. Tourism and recreational use can be expected to increase in the future, however, with judicious development of resources. Great care must be taken to insure against degradation of Alaska's primitive and wilderness values as it develops these resources. The authors present a narrative survey of Alaska's natural recreational resources, such as mountains, volcanoes, glaciers, hot springs, wildlife, game fish, waterfowl, and forests. They describe recreational facilities including National Parks and Monuments, National Forests, and Wildlife Refuges. The report assesses existing and projected problems in the development of a viable recreation program for the Territory and recommends specific solutions to each. Recommendations cover the establishment of a Federal planning authority for Alaska to formulate an integrated policy for the conservation and development of all public lands, including those suitable for recreation; provision for more adequate transportation and other tourist accommodations; enlargement of the existing recreational area system; provision for adequate protection of the existing recreational area system, and the general conservation of natural resources. This classic report contains most of the ideas that were to become the basis of much of the subsequent conservationist sentiment characteristic of one school of thought on resource development planning in Alaska.

KEYWORDS: Planning, sites and facilities, Wilderness and Primitive Areas, wilderness values.

68. Collins, George L.
1953. A survey of the recreation resources of Alaska. *In* Science in Alaska, 1951. 2nd Annu. Alaskan Sci. Conf. Proc., p. 201-208.

The article contains a summary of subjects considered by the National Park Service in preparing a survey of Alaska's recreation resources.

KEYWORDS: Sites and facilities, recreation inventories.

69. Cresap, McCormick and Paget.
1968. A program for increasing the contribution of tourism to the Alaskan economy. 201 p., illus. U.S. Dep. Commer., Washington, D.C.

The purpose of this study and proposal is to exploit Alaska's recreational resources to the fullest possible extent, in view of the study team's findings that tourism could become the third most important industry in the State. The bulk of the report is an exhaustive narrative survey of the existing tourist situation. The high cost of transportation, shortage of overnight accommodations, and the lack of a well-developed promotional program hinder the development of the tourist industry; despite these handicaps, in 1967, 87,000 tourists visited the State, spending $29 million. In terms of toal wages, tourism ranks fourth--after wood products, food processing, and petroleum. If properly developed, Alaska's tourist volume could grow at the rate of 10 percent per year. Such growth would result in a yearly tourist visitation by 1975 of 186,000. Expenditures could exceed $75 million. This could generate 3,900 jobs with wages totaling nearly $28 million. Proposed basic strategy for insuring continued growth is (1) to increase the capacity of Alaska's tourist industry and (2) to attract more tourists to Alaska. The proposal suggests specific measures to accomplish these goals and makes recommendations for the implementation of these measures.

KEYWORDS: Tourism, use projections, use statistics, economic development, planning.

70. Cresap, McCormick and Paget.
1968. Prototype projects: A program for increasing the contribution of tourism to the Alaska economy. [n.p.] U.S. Econ. Dev. Adm., Washington, D.C.

KEYWORDS: Tourism, use statistics, use projections, economic development, planning.

71. Cresap, McCormick and Paget.
1968. Summary of a program for increasing the contribution of tourism to the Alaskan economy. 31 p. U.S. Dep. Commer., Washington, D.C.

This document summarizes the findings and recommendations in "A Program for Increasing the Contribution of Tourism to the Alaskan Economy" (69).

KEYWORDS: Tourism, use statistics, use projections, planning, economic development.

72. Federal Field Committee for Development Planning in Alaska.
1968. A subregional economic analysis of Alaska. 385 p., illus. Fed. Field Comm. Dev. Plann. Alaska, Anchorage.

KEYWORDS: Tourism, economic development, economic analysis.

73. Federal Field Committee for Development Planning in Alaska.
1971. Economic outlook for Alaska. 392 p., illus. Fed. Field Comm. Dev. Plann. Alaska, Anchorage.

KEYWORDS: Tourism, economic analysis, economic development.

74. Forrest, Gladys.
1944. Land resources of Alaska: policies and laws controlling their use, 2. 80 p., illus. North Pac. Study, Portland, Oreg.

This report includes sections on laws and regulations governing forests, agriculture, mineral resources, wildlife, and recreation.

KEYWORDS: Land classification, laws and regulations, administration.

75. Forrest, Linn A.
1947. Tourist development possibilities in Alaska: a survey of potential resort sites. 17 p., illus. Alaska Dev. Board, Juneau.

KEYWORDS: Tourism, sites and facilities, economic development.

76. Fox-Yukon Planning Group.
1971. Fox-Yukon recreation study, November, 1971. 59 p., illus. Fox-Yukon Plann. Group.

KEYWORDS: Planning, sites and facilities.

77. Gabrielson, Ira N.
1952. Alaskan waterfowl and their management. *In* Henry Collins (ed.), Science in Alaska, 1950. sel. pap., 1st Annu. Sci. Conf., p. 292-305.

In the tundra, where most of Alaska's waterfowl live, their existence is jeopardized. This is partly due to the introduction of humans with firearms into the region. To correct this situation the author recommends a wildlife management program that would include the setting aside of specifically protected key breeding areas and the expansion of the existing banding program, the law enforcement staff, and the Cooperative Wildlife Research Unit of the University of Alaska. Research will be the basis of an effective waterfowl management program in the future. The article includes a list of the major species of Alaskan waterfowl, descriptions of the general condition of each species' population, a description of their migration routes, and locations of nesting grounds.

KEYWORDS: Fish and wildlife, wilderness values, management.

78. Gazaway, H. P.
1964. Bureau of Indian Affairs' interest in outdoor recreation in Alaska. 34 p. U.S. Dep. Inter. Bur. Indian Aff., Juneau.

KEYWORDS: Land-use planning, hunting and fishing, sites and facilities, historical and cultural heritage.

79. Grummer Ecosystems Corporation.
1971. A resource inventory and evaluation of the recreational potential of the Wood River-Tikchik area of Alaska. [n.p.] Grummer Ecosystems Corp., Bethpage, N. Y.

KEYWORDS: Recreation inventories, planning, State parks, sites and facilities.

80. Hersh, Adolph E.
1972. Parks, recreation and school sites study. 212 p., illus. Fairbanks North Star Borough, Alaska Housing Auth., Fairbanks.

Fairbanks needs more and better local recreation facilities. Some support for their development is available in the form of Federal and State grants. All favored recreation activities of Fairbanks residents are related to parks, trails, or organized sports and activities. Since swimming is the most desired of warm weather activities, Fairbanks needs more swimming pools. Agencies must actively involve citizens in the planning, construction, and maintenance of new urban park facilities to offset the adverse effects of low funding. The report proposes the formation of a nine-man parks and recreation commission to oversee the development and maintenance of Fairbanks' municipal parks system. Financial support for borough operation of recreation will derive partly from a $5 per capita State revenue sharing measure that should produce an annual income of about $165,000. Revenues from fees and special charges may return an additional sum of about $10,000 to support borough recreation. Among the major developments the plan proposes is the erection of a civic activities center, six metropolitan parks of 100 to 500 acres or more, and three of 50 acres and larger for nature study purposes.

KEYWORDS: Planning, municipal parks, sites and facilities, administration.

81. Johnson, Hugh A., and Harold T. Jorgenson (eds.).
1963. The land resources of Alaska: a Conservation Foundation study. 551 p., illus. Univ. Publ., College [Fairbanks], Alaska.

Tourism and outdoor recreation is the third largest industry in Alaska. Several factors prevent it from becoming an even more significant economic force: the generally low population of Alaska itself; the lack of comfortable, conveniently located overnight facilities (both in the cities and along access routes); the lack of finished access routes; and the lack of steamship access from the lower 48 States. A well-balanced State Park System would contribute to continued growth of the tourist industry in Alaska. The authors provide narrative analyses of the present uses, administrative problems, and future recreation needs in Alaska of the U.S. Forest Service, National Park Service, National Wildlife Refuge System, Federal public domain, and the State Park System. Tables are included.

KEYWORDS: Tourism, National Parks and Monuments, wildlife refuges and ranges, use projections, National Forests, State parks, access, economic development, use statistics, planning, management.

82. Loll, Leo M.
1967. A study of technical and economic problems: State of Alaska. Univ. Alaska, Inst. Soc., Econ., and Gov. Res., SEG Rep. No. 13, 173 p., illus. College [Fairbanks].

The section on tourism concludes that Alaska must offer facilities for tourists at more reasonable rates, or the growing tourist industry will level off. The Marine Highway System is adequate to encourage an increasing number of visitors each year.

KEYWORDS: Tourism, use statistics, planning, access, sites and facilities, economic development.

83. McCracken, Harold.
1924. The game situation in Alaska. Am. For. 39(366):323-328, 362, illus.

Depletions of game by the Alaskan Natives, market hunters, and workmen in canneries and construction camps illustrate the need for an Alaskan game act to regulate game conditions effectively.

KEYWORDS: Hunting and fishing, fish and wildlife, historical and cultural heritage, laws and regulations.

84. Mills, Wilbur.
1962. The Canning River region, Alaska: a survey of its wilderness and recreation resources. (Mimeogr.) 46 p., illus. Sierra Club, New York.

The author surveyed the Canning River region first-hand, reviewed it as a recreation resource and recommends that the utility-transportation corridor along the west side of the Canning and the Marsh Fork be abolished; a 2-mile-wide scenic easement along the lower Canning west of the present Arctic Wildlife Range boundary be reserved; and that all lands lying within the Canning drainage south of benchmark "Ignek," including the Marsh Fork, be added to the Range. He also recommends that the 627,000-acre Canning addition to the Range be managed as a legally designated Wilderness.

KEYWORDS: Land classification, Wilderness and Primitive Areas, wilderness values, administration, wildlife refuges and ranges, lakes and waterways.

85. Mills, Wilbur M.
1970. Environmental degradation in the Arctic National Wildlife Range. (Mimeogr.) 6 p. Seattle Mountaineers, Seattle.

During the spring and summer of 1970, the author observed many instances of alleged abuse of the Arctic National Wildlife Range by oil companies exploring there. He enumerates specific instances of degradation of the Range in this report and recommends action on the part of the Department of the Interior (which administers the Range through its Fish and Wildlife Service), and by concerned citizens, to halt the damaging activity. He recommends that the Range be closed to all oil and mineral leasing, exploration, and development until Congress can review the area under the terms of the Wilderness Act; that studies be initiated to develop an overall management and land-use plan for the Arctic Range; that the Department of the Interior acquire the abandoned DEW (distant early warning) line sites at Simpson Cove and Demarcation Point for inclusion in the Wildlife Range; that debris at Schrader Lake, Lobo Lake, and other areas which receive recreational use be removed from the Range; that the Department of Interior acquire the Interior Airways camp at Schrader Lake; that the southern boundary of the Arctic Range be reviewed for possible inclusion of such areas as the complete drainage of Old Woman Creek and the entire length of the Sheenjek and Coleen Rivers; and that efforts be initiated with the Canadian government toward establishing a wildlife reserve in northwestern Yukon Territory adjacent to the Arctic Wildlife Range.

KEYWORDS: Wilderness and Primitive Areas, wildlife refuges and ranges, wilderness values.

86. National Audubon Society.
1967. Survey report and plan: Alaska Nature Center, Fairbanks North Star Borough, Alaska. 62 p. Natl. Audubon Soc., New York.

KEYWORDS: Sites and facilities, municipal parks, planning, fish and wildlife.

87. National Resources Committee, and Alaska Resources Committee.
1938. Regional planning, part 7: Alaska: its resources and development. 213 p., illus. Gov. Print. Off., Washington, D.C.

Alaska's resources for recreation and tourism are vast but underused because of small population, great distances, and lack of highways. The report presents a description of recreation resources, including existing National Forests, Parks, and Monuments. It recommends establishment of a Federal planning authority for Alaska to formulate conservation and development policy, provision for more adequate transportation, and enlargement of the existing recreational system. The primitive or frontier quality of Alaska's recreational resources is distinctive and must be emphasized and maintained.

KEYWORDS: Access, National Forests, National Parks and Monuments, planning, wilderness values, administration, Wilderness and Primitive Areas.

88. Smith, Theodore G.
1969. Alaska State Park System, 1970-1976. 24 p., illus. Alaska Div. Lands, Anchorage.

The basic objectives of the State Park System in Alaska are to provide "a wide-range of recreational opportunities for residents and visitors; to preserve...significant objectives and sites from the past; and to preserve and protect the values associated with Alaska's cultural and wilderness heritage." The report outlines policies to implement these objectives.

The Alaska State Department of Parks estimates it will spend $1,780,000 by 1976 on improvements of waysides; $12,140,000 for the development of destination areas; $860,000 for the development of historic sites; and $800,000 for studies and development of trails in recreation corridors and wilderness areas. Funding is anticipated from the 1966 Outdoor Recreation Bond Fund, general fund, special tax revenues, bond issues, Division of Water and Harbors, Department of Fish and Game, and Federal grants. Tables are included.

KEYWORDS: State parks, land-use planning, planning, sites and facilities, administration.

89. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, Arctic region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 83 p., illus.

This report and the reports of 90, 91, 92, 93, and 94 contain an introduction to the region and its resources, a subregional inventory of developed and potential recreation and preservation opportunities, appendixes that include the quality evaluation rating system used in the survey, a glossary, and a bibliography. Each report is illustrated with maps.

KEYWORDS: Sites and facilities, recreation inventories.

90. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, northwest region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 89 p., illus.

See Abstract for 89.

KEYWORDS: Sites and facilities, recreation inventories.

91. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, southcentral region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 166 p., illus.

See abstract for 89.

KEYWORDS: Sites and facilities, recreation inventories.

92. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, southeast region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 117 p., illus.

See abstract for 89.

KEYWORDS: Sites and facilities, recreation inventories.

93. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, southwest region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 72 p., illus.

See abstract for 89.

KEYWORDS: Sites and facilities, recreation inventories.

94. Stenmark, Richard J., and Thomas H. Schoder.
1974. Resources inventory, Yukon region: recreation and preservation opportunities. Resour. Plann. Team, Joint Fed.-State Land Use Plann. Comm., 138 p., illus.

See abstract for 89.

KEYWORDS: Sites and facilities, recreation inventories.

95. Thomas, Wayne C., and Gregory K. White.
1974. Outdoor recreation responsibilities in Alaska. 45 p., illus. Alaska Div. Parks [Anchorage].

The goals of the study are (1) to evaluate existing jurisdictional and funding responsibilities for providing outdoor recreation in Alaska and (2) to recommend improvements in availability of outdoor recreation to the general public. The general analysis of the Federal, State, and local agencies responsible for Alaska's recreational resources revealed little cooperation or coordination among them, often resulting in actions at cross-purposes. "Alaska would benefit if all (recreation) agencies would recognize common objectives for the State's recreational system and coordinate their efforts to maximize the public benefits...." The study makes five specific recommendations to foster improved interagency communication.

KEYWORDS: State parks, planning, administration.

96. Thomas, Wayne C., Gregory K. White, and Nat Goodhue.
1974. Catalogue of assistance for outdoor recreation projects. 80 p., illus. Alaska Div. Parks.

The purpose of this catalog of programs is to provide a single, convenient reference for those seeking assistance in expanding outdoor recreation opportunities in Alaska. It contains active, funded programs which may be used to support outdoor recreation.

KEYWORDS: Administration, planning.

97. Thompson, Linda Kay.
1972. Alaska's abandoned towns. Alaska Div. Parks, Hist. Arch. Ser. 2, Misc. Publ., 75 p., illus. Anchorage.

This study, through three case studies, seeks to establish the importance of three abandoned mining communities as evidence of Alaska's past. It identifies problems in protection and interpretation and recommends solutions that may apply in the preservation of other historic remains.

KEYWORDS: Historical and cultural heritage, planning.

98. U.S. Alaska Highway and Land Planning Survey Committee.
1944. Recreation resources of the Alaska Highway and other roads in Alaska. 83 p., illus. U.S. Dep. Inter. Natl. Park Serv., Washington, D.C.

This older classic study inventories the recreation resources of the Alaska Highway and other roads in Alaska. Introductory chapters deal with the allure of Alaska and means of access to Alaska. The report fully describes each road and discusses future access roads, factors influencing volume of use, quantitative estimates of use, and temporary accommodations. Later sections offer a plan for development of recreation facilities and procedures for their implementation. Finally, the study summarizes significant findings and makes major recommendations.

KEYWORDS: Highways and roads, use projections, sites and facilities, land-use planning, land classification, tourism, recreation inventories, access, planning.

99. U.S. Department of Agriculture, Forest Service.
1969. Assessing benefits and costs for Alaska National Forest wilderness proposals. (Mimeogr.) 4 p. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Land classification, Wilderness and Primitive Areas, economic analysis.

100. U.S. Department of Agriculture, Forest Service.
1973. New National Forests for Alaska. 284 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

This report is a revision of an earlier report (122) reflecting changes in the final land withdrawals made by the Secretary of the Interior in September 1972. It presents the final proposals for the creation of new National Forests in Alaska as one of the four National Conservation Systems designated under Section 17(d) (2) of the Alaska Native Claims Settlement Act. The report was designed for the use of the House Public Lands Subcommittee in their review of the Secretary's recommendation. It includes detailed descriptions of seven proposed new National Forests (Wrangell Mountains, Fortymile, Porcupine, Koyukuk, Yukon, Kuskokwim, Lake Clark), totaling exactly 42 million acres, and is illustrated with charts, graphs, maps, photos, and drawings.

KEYWORDS: Land classification, National Forests, Alaska Native Claims Settlement Act, administration, laws and regulations.

101. U.S. Department of Agriculture, Forest Service.
1974. New National Forests for Alaska. U.S. Dep. Agric. For. Serv., Curr. Inf. Rep. 12, 12 p., illus.

A USDA Forest Service study team, along with teams from three other Federal natural resource agencies, framed an analysis and recommendations for land classification changes in Alaska. The Forest Service team selected 39.4 million acres in seven areas suitable for new units in the National Forest System and 2.6 million acres for additions to the present Tongass and Chugach National Forests. The Secretary of the Interior recommended three new major National Forests totaling 18.3 million acres and one-half million additional acres for the Chugach National Forest. Tables and maps show details of the proposals of the Forest Service and the Secretary of the Interior.

KEYWORDS: Land classification, National Forests, Alaska Native Claims Settlement Act, administration, laws and regulations.

102. U.S. Department of Commerce, National Marine Fisheries Service, Alaska Region.
1974. Marine recreational fishing in Alaska. MFR Pap. 1042, Mar. Fish. Rev. 36(3):18-20.

Marine fishing is an increasingly popular pastime for Alaskans and visitors. Increase in use has given rise to conflicts; for example, between sport and commercial fishermen and between the United States and Canada over ownership of coho and chinook salmon. The National Marine Fisheries Service can and should contribute to the solution of these and other problems.

KEYWORDS: Hunting and fishing, lakes and waterways, fish and wildlife.

103. U.S. Department of Health, Education and Welfare.
1972. Environmental health practices in Alaska recreation areas. (Seminar.) 50 p. U.S. Dep. Health, Educ. and Welfare. Publ. Health Serv., Health Serv. and Mental Health Admin. Bur. Community Environ. Manage. [May 31, June 1 and 2, 1972, Fairbanks.]

KEYWORDS: Sites and facilities, management.

104. U.S. Department of the Interior.
1965. Recreation opportunities. *In* Rampart project, Alaska: market for power and effect of the project on natural resources. Vol. 1, part 4, p. 319-336. U.S. Dep. Inter., Juneau.

KEYWORDS: Rampart Dam.

105. U.S. Department of the Interior.
1965. Recreation resources and recreational effects of the project. *In* Rampart project, Alaska: market for power and effect of the project on natural resources. Vol. 3, part 10, p. 979-987. U.S. Dep. Inter., Juneau.

KEYWORDS: Rampart Dam.

106. U.S. Department of the Interior, Bureau of Land Management.
1971. Iliamna unit resource analysis: Bristol Bay resource area, Anchorage District, Alaska. 200 p., illus. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

The resource analysis contains a section on recreation, about 25 pages. It includes assessments of the scenery, wildlife, cultural features, geologic features, water bodies, snow and ice features, ecological features, primitive values, and recreation sites of the unit as to their value to outdoor recreationists. The information included in the report was obtained from written sources, not from direct observation. It does not constitute an inventory, according to the authors, who declare that more inventory work is needed on the unit.

KEYWORDS: Sites and facilities.

107. U.S. Department of the Interior, Bureau of Land Management.
1971. Prospectus for land-use planning in northern Alaska. (Draft copy.) 12 p., illus. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

KEYWORDS: Land-use planning.

108. U.S. Department of the Interior, Bureau of Outdoor Recreation.
1971. Recreation impact study: Trans-Alaska pipeline, for the Bureau of Land Management. 64 p. U.S. Dep. Inter. Bur. Outdoor Recreation.

Construction of the pipeline can have an adverse effect on Alaska's recreation resources, but impact on use will be generally beneficial. Physical impacts of the pipeline threaten certain characteristics of both the Gulkana and Delta Rivers, each a possible condidate for the Wild and Scenic Rivers System. Visual impacts of the construction may be less significant, but Keystone Canyon needs special care and planning, as do the areas near Worthington Glacier, Isabel Pass, and hundreds of pit areas for gravel. North of the Yukon River, the opening up of an existing wilderness could be the maximum pipeline impact.

The pipeline will stimulate recreation use of Alaska's resources. Overall participation in outdoor recreation is sure to increase somewhat faster than without oil industry expansion, especially along the segments north of the Yukon River.

This report presents suggestions which are intended to minimize adverse impacts of the pipeline and to utilize and improve those areas affected by pipeline construction for maximum public benefits. Comprehensive master planning will be necessary to assure proper utilization of the pipeline right-of-way, material sites, and lateral access roads. New highways built in conjunction with the pipeline should be constructed so as to have little adverse effect on the Alaskan environment. Areas of particular value, such as Galbraith Lake and the Yukon River, should be protected. Construction camps and service areas and campgrounds can be made useful to recreationists. New recreation facilities could be operated on a concessionaire basis. Additional recreation areas should be identified. Use of off-the-road vehicles should be limited, and pipeline support facilities should be located and designed to be compatible with the surrounding environment.

KEYWORDS: Wilderness values, economic development, planning, management.

109. U.S. Department of the Interior, Fish and Wildlife Service.
[n.d.] Aleutian Islands: wilderness study summary. 34 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv., Anchorage.

The Aleutian Islands National Wildlife Refuge possesses some outstanding wilderness values. Approximately 1,395,357 acres appear suitable for inclusion in the National Wilderness Preservation System. Approximately 325,362 acres of the study area appear unsuitable for wilderness designation. These excluded areas would provide for military operations and future expansion of the fish industry, as well as for Aleut land selections under the Alaska Native Claims Settlement Act. In addition, numerous cemeteries and historical sites may be selected by the Natives. Since waters below the line of mean high tide are not under Refuge jurisdiction, motorboats may be used for commercial fishing and for access to the island beaches and lagoons. Aircraft may also land in these waters and within excluded areas.

KEYWORDS: Wildlife refuges and ranges, Wilderness and Primitive Areas, fish and wildlife, land classification.

110. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
[n.d.] Nunivak wilderness study summary. 24 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv. Bur. Sport Fish. and Wildl., Anchorage.

Although Nunivak National Wildlife Refuge possesses many wilderness qualities, it is proposed that it not be designated a Wilderness Area in the National Wilderness Preservation System. The most serious conflict with wilderness appears to be the use of snow machines by Native residents for both subsistence and recreational purposes. Such use is viewed incompatible with wilderness protection and management under terms of the Wilderness Act of 1964. The other conflicts involve the commercial reindeer herding enterprise, pending Native land selections, imprecise refuge boundary, the proposed road corridor around the entire island, and the military's entitlement to use of the refuge.

KEYWORDS: Wildlife refuges and ranges, land classification, Wilderness and Primitive Areas, fish and wildlife.

111. U.S. Department of the Interior, National Park Service.
1964. Alaska. *In* Parks for America, p. 345-354. Gov. Print. Off., Washington, D.C.

Behind national defense, fisheries, and forest products, recreation was the most important industry in Alaska in 1964. Population projections suggest the need for expanded recreation facilities in the near future. Therefore, the National Park Service should give further study to proposals to establish as National Parks the St. Elias-Wrangell Mountains, Lake Clark Pass, and the Wood-Tikchik area; the State Park Service should enlarge its system by placing under its administration 17 parks, 27 recreation areas, 3 scientific monuments, 2 historic monuments, and 1 nature preserve, as well as scenic routes, free-flowing streams, and foot trails; and local park departments should establish 3 parks, 14 recreation areas, 1 beach trail, and 1 foot trail. The study includes an inventory of existing Federal, State, and local recreation areas.

KEYWORDS: Land classification, planning, use projections.

112. U.S. Department of the Interior, National Park Service.
1971. Wilderness study: Katmai National Monument. (Prelim. draft.) 19 p., illus. U.S. Dep. Inter. Natl. Park Serv., Seattle.

Lands and waters of the portion of the Aleutian Range and Lake District comprising most of Katmai National Monument, Alaska, have been found suitable for inclusion in the National Wilderness Preservation System.

KEYWORDS: Wilderness and Primitive Areas, land classification, National Parks and Monuments, administration.

113. U.S. Department of the Interior, National Park Service.
1974. Proposed Katmai Wilderness, Katmai National Monument, Alaska: final environmental statement. U.S. Dep. Inter. Natl. Park Serv., Pac. Northwest Reg., 204 p., illus.

KEYWORDS: Land-use planning, Wilderness and Primitive Areas, National Parks and Monuments, fish and wildlife, land classification, administration, planning.

114. University of Alaska, Institute of Business, Economic and Government Research.
1965. Tourism in Alaska. 20 p., illus. Univ. Alaska Inst. Bus., Econ., and Gov. Res., College [Fairbanks].

Tourism is already a major source of income for the State of Alaska and its residents; aggressive promotion would insure the continued growth of the tourist industry. State and private interests must expand tourist facilities to meet growing needs and give greater attention to long-range policies and plans to attract more tourist money to Alaska. Alaska may expect 200,000 or more visitors by 1975, even without well-organized support for developmental programs; but this number could increase to 450,000 with that support, bringing into the State an estimated $225 million annually. A developmental program should include (1) an inventory of existing facilities, (2) measurement of present levels of use, and (3) a study of actual and potential growth.

KEYWORDS: Tourism, sites and facilities, use projections, economic development.

115. Westgate, Richard S., and Victor Fischer.
1954. Volume 1 of part 2, Community and territorial recreation, Alaska recreation survey. 35 p., illus. U.S. Dep. Inter. Natl. Park Serv. Gov. Print. Off., Washington, D.C.

This volume discusses recreation facilities, programs, and activities offered by the various agencies and programs in Anchorage. Numerous recommendations are made for improvement of recreation opportunities in Anchorage.

KEYWORDS: Municipal parks, planning, management, administration.

116. Wilson, Carl N.
1959. The National Forest outdoor recreation resource review in Alaska. *In* Science in Alaska. 10th Alaskan Sci. Conf. Proc., p. 103-104. [Juneau.]

The Forest Service is undertaking an outdoor recreation resources review of all the National Forests, including Alaska's, with the specific objectives of making an inventory and evaluation of recreation resources and reviewing the policies, plans, and programs needed to meet future recreation demands on the National Forests. This information will be furnished to the National Outdoor Recreation Resources Review Commission in preparing their report.

KEYWORDS: National Forests, recreation inventories.

117. Wolf Management Service.
1965. Investment opportunities in southeastern Alaska. 244 p., illus. U.S. Dep. Commer., Area Redev. Adm. Gov. Print. Off., Washington, D.C.

The Alaska Marine Highway System is a force for economic growth in many areas--tourism among them. The report examines the abilities and limitations of the System as one key to solving the underemployment problem and offers recommendations and conclusions to enable southeastern Alaska's economic climate to improve.

KEYWORDS: Tourism, Alaska Marine Highway System, economic development, highways and roads, access, economic analysis.

B. PROPOSALS

118. Alaska Office of the Governor, Planning and Research.
1975. A preliminary proposal pertaining to national interest ("D-2") lands in Alaska under the Alaska Native Claims Settlement Act. 26 p. Alaska Off. Governor, Plann. and Res., Juneau.

KEYWORDS: Alaska Native Claims Settlement Act, land classification.

119. Burkhart, Wayne, and Marilyn Burkhart.
1967. A tourist facility and recreation area in Alaska's Matanuska Valley. 9 p. Matanuska Valley Parks and Recreation, Inc.

KEYWORDS: Sites and facilities, tourism, planning.

120. Mills, Wilbur.
1961. A proposed addition to the Arctic National Wildlife Range. (Prelim. draft.) 30 p., illus. Seattle Mountaineers, Seattle.

Approximately 5 million acres of the Sheenjek and Coleen River drainages south of the present boundary should be added to the Arctic National Wildlife Range.

KEYWORDS: Land classification, Wilderness and Primitive Areas, wilderness values, wildlife refuges and ranges, administration.

121. Sitka Conservation Society.
1968. A proposal: the West Chichagof-Yakobi Island Wilderness. 9 p. Sitka Conserv. Soc., Sitka, Alaska.

KEYWORDS: Land classification, Wilderness and Primitive Areas, National Forests.

122. U.S. Department of Agriculture, Forest Service.
1972. A proposal for new National Forests for Alaska under the Alaska Native Claims Settlement Act. U.S. Dep. Agric. For. Serv., Situation Rep., 12 p., illus.

KEYWORDS: Land classification, Alaska Native Claims Settlement Act, National Forests, administration, laws and regulations.

123. U.S. Department of Agriculture, Forest Service.
[n.d.] Wrangell Mountains National Forest. (Proposal) 60 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Land-use planning, land classification, Wilderness and Primitive Areas, National Forests.

124. U.S. Department of the Interior.
1974. Noatak National Arctic Range, Alaska: final environmental statement. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

This statement and the statements in 125, 126, 127, 128, 129, 130, 131, and 132 contain the resource review and environmental evaluations creating wildlife refuges and include public comments.

KEYWORDS: Wildlife refuges and ranges.

125. U.S. Department of the Interior.
1974. Proposed Alaska Coastal National Wildlife Refuge, Alaska: final environmental statement. 678 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

126. U.S. Department of the Interior.
1974. Proposed Arctic National Wildlife Refuge, Alaska: final environmental statement. 668 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

127. U.S. Department of the Interior.
1974. Proposed Iliamna National Resource Range, Alaska: final environmental statement. 620 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

128. U.S. Department of the Interior.
1974. Proposed Koyukuk National Wildlife Refuge, Alaska: final environmental statement. 576 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

129. U.S. Department of the Interior.
1974. Selawik National Wildlife Refuge, Alaska: final environmental statement. 632 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

130. U.S. Department of the Interior.
1974. Togiak National Wildlife Refuge, Alaska: final environmental statement. 546 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

131. U.S. Department of the Interior.
1974. Yukon Delta National Wildlife Refuge, Alaska: final environmental statement. 550 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

132. U.S. Department of the Interior.
1974. Yukon Flats National Wildlife Refuge, Alaska: final environmental statement. 646 p., illus. U.S. Dep. Inter., Alaska Plann. Group, Washington, D.C.

See abstract for 124.

KEYWORDS: Wildlife refuges and ranges.

133. U.S. Department of the Interior, Bureau of Land Management.
1963. Guidelines for outdoor recreation programs in Alaska: a proposal. 13 p. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

KEYWORDS: Sites and facilities, planning, administration, management.

134. U.S. Department of the Interior, Bureau of Land Management.
1971. The Central Brooks Range classification: a proposal. 24 p., illus. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

The purpose of this publication is to foster public understanding of and support for the classification of the Central Brooks Range for multiple use management by the Bureau of Land Management. Emphasis is placed on the Range's primary value as Wilderness rather than as a timber and mineral resource.

KEYWORDS: Land-use planning, land classification, Brooks Range, wilderness values, administration.

135. U.S. Department of the Interior, Bureau of Land Management.
[n.d.] Proposed classification for multiple use management: Copper River area. 5 p., illus. U.S. Dep. Inter. Bur. Land Manage., Anchorage.

KEYWORDS: Land-use planning, land classification, sites and facilities.

136. U.S. Department of the Interior, Bureau of Outdoor Recreation.
1970. Wrangell Mountains National Scenic Area. 33 p., illus. U.S. Dep. Inter. Bur. Outdoor Recreation, Washington, D.C.

This publication is a proposal for the Copper and Chitina River area.

KEYWORDS: Scenery, National Scenic Areas.

137. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. 1970. Izembek wilderness proposal, Alaska. 20 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Anchorage.

KEYWORDS: Wilderness and Primitive Areas, land classification, fish and wildlife, wildlife refuges and ranges, administration, hunting and fishing.

138. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife. 1971. Kenai wilderness proposal: Kenai National Moose Range, Alaska. 31 p., illus. U.S. Dep. Inter. Bur. Sport Fish and Wildl., Anchorage.

KEYWORDS: Wilderness and Primitive Areas, land classification, fish and wildlife, Kenai Peninsula, wildlife refuges and ranges, hunting and fishing, administration.

139. U.S. Department of the Interior, Fish and Wildlife Service. 1974. Proposed Alaska National Wildlife Refuges. [n.p.], illus. U.S. Dep. Inter. Fish and Wildl. Serv.

This publication contains about 200 pages, comprised of nine brochures, illustrated with maps and photos, of the nine proposed National Wildlife Refuges: Yukon Delta, Koyukuk, Yukon Flats, Selawik, Iliamna, Arctic, Noatak (National Arctic Range), Alaska Coastal, and Togiak. The material is primarily descriptive.

KEYWORDS: Wildlife refuges and ranges.

140. U.S. Department of the Interior, Fish and Wildlife Service. 1975. Environmental assessment: proposed management of muskox on Nunivak National Wildlife Refuge, Alaska. 101 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv., Anchorage.

The Fish and Wildlife Service proposes to maintain the muskox herd on Nunivak National Wildlife Refuge within the average carrying capacity of its winter range. Management programs will require reduction in the size of the herd by a variety of means including permit hunts to be managed in cooperation with the Alaska Department of Fish and Game. Unchecked increase of the muskox population on Nunivak has resulted in heavy winter mortality which threatens the future of the herd, progressive destruction of vegetation in areas used as winter range, and in increased erosion of coastal dunes, unique natural features of the island. This proposal will provide additional security to muskox on Nunivak by maintaining the population within the carrying capacity of their winter range. Destruction of vegetation and the progressive erosion of important dune habitats will be retarded. The proposal will maximize economic and recreational benefits from management of the herd and will result in a significant contribution to the economy of the Eskimo village of Mekoryuk. There are no significant adverse impacts on the human or wildlife-wildlands environment of Nunivak Island.

KEYWORDS: Fish and wildlife, hunting and fishing, wildlife refuges and ranges.

141. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
[n.d.] Chamisso wilderness proposal. 10 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv. Bur. Sport Fish. and Wildl., Portland, Oreg.

The Chamisso National Wildlife Refuge is suitable for preservation within the National Wilderness Preservation System--a designation which would be entirely compatible with existing refuge objectives.

KEYWORDS: Wildlife refuges and ranges, Wilderness and Primitive Areas, fish and wildlife, land classification.

142. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
[n.d.] Semidi wilderness proposal: Semidi National Wildlife Refuge, Alaska. 16 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv. Bur. Sport Fish. and Wildl., Anchorage.

All of the Semidi National Wildlife Refuge is still in a natural state and qualifies for inclusion in the National Wilderness Preservation System. No adverse economic or environmental impacts can be foreseen from the proposed action. Commercial fishing with motor-powered boats is an established use and does not conflict with management objectives. It is proposed that this activity be permitted to continue subject only to existing Federal and State laws. Designating the Semidi National Wildlife Refuge as wilderness will provide legislative protection to the Refuge and will assure that the insular ecosystem will remain in a natural state for the use and enjoyment of this and future generations of Americans.

KEYWORDS: Wildlife refuges and ranges, fish and wildlife, land classification, Wilderness and Primitive Areas.

143. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
[n.d.] Simeonof wilderness proposal, Alaska. 10 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv. Bur. Sport Fish. and Wildl., Portland, Oreg.

All lands and waters of the Simeonof National Wildlife Refuge, with the exception of the lands presently occupied by old ranch buildings, are recommended as suitable for consideration as Wilderness. Under Wilderness designation, the existing grazing program would be continued, to the extent compatible with refuge and wilderness objectives.

KEYWORDS: Wildlife refuges and ranges, fish and wildlife, Wilderness and Primitive Areas, land classification.

144. U.S. Department of the Interior, Fish and Wildlife Service, Bureau of Sport Fisheries and Wildlife.
[n.d.] Unimak Island: Aleutian Islands National Wildlife Refuge, Alaska: wilderness proposal. (Prelim. draft.) 21 p., illus. U.S. Dep. Inter. Fish and Wildl. Serv. Bur. Sport Fish and Wildl., Anchorage.

Approximately 965,042 acres of the nearly 1-million-acre Unimak Island appear suitable for inclusion in the National Wilderness Preservation System. Nonmotorized recreational pursuits such as camping, hiking, mountain climbing, sport hunting and fishing, beachcombing, picnicking, berrypicking, nature study, outdoor photography, and wildlife observation and study would be encouraged in the Unimak Wilderness. Small aircraft and motorboats are the established means of access to the island and would continue to be permitted with wilderness designation. Motorboats could continue to be used to reach island beaches and lagoons but would not be allowed on the interior lakes. Because they are incompatible with Wilderness, vehicles such as jeeps, trail bikes, snowmobiles, dune buggies, and all-terrain vehicles would be prohibited within the Unimak Wilderness Area.

KEYWORDS: Wilderness and Primitive Areas, land classification, wildlife refuges and ranges.

145. U.S. Department of the Interior, National Park Service.
1971. Klondike Gold Rush National Historical Park, Alaska. (Prelim. draft.) 43 p., illus. U.S. Dep. Inter. Natl. Park Serv., Seattle.

A special study, prepared as a part of the National Survey of Historic Sites and Buildings, identified the town of Skagway and the surrounding area--the Chilkoot Pass, White Pass, the town of Dyea, and the Klondike Gold Rush Trail--as being of "exceptional value in commemorating the history of the United States." The town of Skagway alone is not financially capable of preserving and maintaining its historic sections. A cooperative, interagency historic preservation effort is needed. The component parts of the proposed historical park would be: (1) Skagway Historic District, (2) Chilkoot Pass and Trail, (3) White Pass and Trail, (4) portions of the townsite of Dyea, and (5) an international Klondike Gold Rush Trail. The city, the State, the U.S. Government, the Canadian government, and the White Pass and Yukon Railroad would all contribute to the preservation effort, according to the plan. The report is illustrated with resource and planning maps and contains appendixes describing the area and its resources in detail.

KEYWORDS: National Parks and Monuments, historical and cultural heritage, land classification, sites and facilities, administration, planning.

C. PLANS AND PROGRAMS

146. Alaska Consultants.
1968. Nome comprehensive development plan. 162 p. Alaska Housing Auth., Anchorage.

Page 67 is on tourism. Pages 136-139 are on parks and recreation.

KEYWORDS: Planning, municipal parks, tourism.

147. Alaska Consultants.
1968. Teller comprehensive plan. 105 p. Alaska Housing Auth., Anchorage.

Pages 80-83 are on parks and recreation.

KEYWORDS. Planning, municipal parks.

148. Alaska Department of Natural Resources.
1970. Alaska outdoor recreation plan, volume 1 (summary). 42 p., illus. Alaska Dep. Nat. Resour., Juneau.

Volume 1 briefly summarizes the contents of the other three volumes (149, 150, 151) and constitutes a document suitable for general distribution. Earlier plans qualified Alaska for funds provided under the Land and Water Conservation Fund Act; this plan updates those plans. Included are sections on resource description, present demand, forecast demand and indicated needs, and recommendations, as well as a statewide inventory of areas and facilities and an analysis of user participation.

KEYWORDS: Use statistics, use projections, sites and facilities, recreation inventories, planning, administration.

149. Alaska Department of Natural Resources.
1970. Alaska outdoor recreation plan, volume 2: Outdoor recreation in Alaska. 180 p., illus. Alaska Dep. Nat. Resour., Juneau.

Volume 2 presents fundamental information about Alaska's recreation resources, needs, and problem areas. One section inventories Alaska's recreation resources, region by region, including high density areas, general outdoor recreation areas, natural environment areas, unique natural areas, primitive areas, and historical and cultural sites. The study surveys and analyzes user demand, concentrating on 14 major recreation activities under the headings: trail-related activities (including skiing, climbing, bicycling, etc.), sightseeing, driving for pleasure, picnicking, and fishing. From these data, the plan concludes that between 1970 and 1975 the need for recreation facilities will increase from 50 to 300 percent; there will be a particularly high demand for more bicycle paths, hiking and horseback riding trails, developed campsites, ice skating areas, swimming pools, and developed beaches; urban areas will receive especially heavy demand; development of joint access-recreation facilities (roadways, trails, airstrips, etc.) will require special attention; existing areas and facilities will require improvement and promotion to insure their full utilization.

KEYWORDS: Use statistics, use projections, sites and facilities, planning, recreation inventories, administration.

150. Alaska Department of Natural Resources.
1970. Alaska outdoor recreation plan, volume 3: plan of action for implementation. 52 p., illus. Alaska Dep. Nat. Resour., Juneau.

Volume 3 reviews the major recommendations and needs developed in volume 2. Major recommendations are: (1) the State administration should adopt a position of strong leadership in matters affecting recreation planning and environmental conservation in Alaska; (2) the finest features of the Alaskan environment and potential recreation areas should be identified and preserved as part of a comprehensive land-use planning procedure; (3) Federal, State, local, quasi-public, and private agencies should invest in a $35 million to $45 million recreation development program between 1970 and 1975; (4) all levels of government in Alaska should place special emphasis on meeting recreational needs in and near cities and villages; (5) the newly reorganized Alaska Outdoor Recreation Council should be further strengthened to become the clearinghouse for outdoor recreation affairs in Alaska; (6) Alaska's systems of recreational access should be enlarged and improved; and (7) provisions of the Land and Water Conservation Fund should be revised to provide greater benefits to Alaska. Volume 3 reviews present recreation resources and projects needs and demands to 1975. Allocation of the jurisdictional and funding responsibilities of public, quasi-public, and private agencies is outlined in the plan; and a schedule of acquisition and development for all agencies is proposed. Finally, the plan makes recommendations for continued recreation planning.

KEYWORDS: Land-use planning, sites and facilities, planning, administration, use statistics, use projections.

151. Alaska Department of Natural Resources.
1970. Alaska outdoor recreation plan, volume 4: appendixes. 66 p., illus. Alaska Dep. Nat. Resour., Juneau.

Volume 4 contains the appendixes for the plan. Included are the glossary, inventory forms, programed inventory data, definitions of activities, the resident questionnaire, the nonresident mail-back questionnaire, descriptions of techniques used for estimating demand, the forecasted needs for selected activities, and extensive bibliography.

KEYWORDS: Use statistics, use projections, bibliography, sites and facilities, administration, planning.

152. Alaska Division of Lands.
[n.d.] Nancy Lake plan, program, budget. 69 p. Alaska Div. Lands, Anchorage.

KEYWORDS: Sites and facilities, planning, administration.

153. Alaska Division of Lands, Branch of Parks and Recreation.
1966. Alaska public outdoor recreation plan, 1st revision. 72 p. Alaska Div. Lands, Branch Parks and Recreation.

The plan breaks the State into five regions, describes the regions' resources relative to recreation, and lists agencies involved in outdoor recreation and their policies, objectives, and functions. This revision actually contains only parts II, IV, and V of the original State plan. Parts I and III were not revised or included in this report. Part II includes a survey of existing recreation resources. Part IV analyzes recreation demand and future needs. Part V consists of recommendations for implementation of the program.

KEYWORDS: Sites and facilities, management, planning, administration, State parks.

154. Alaska Division of Lands, Branch of Parks and Recreation.
1967. Alaska public outdoor recreation plans: an abstract. 24 p. Alaska Div. Lands, Branch Parks and Recreation, Anchorage.

This is a general summary of outdoor recreation in the State, with sections on supply, demand, needs, and action plans.

KEYWORDS: Sites and facilities, use projections, planning, State parks, administration.

155. Alaska Division of Parks.
1974. Comprehensive master plan for the proposed Wood-Tikchik State Park. 55 p., illus. Alaska Div. Parks, Anchorage.

KEYWORDS: Planning, State parks, sites and facilities.

156. Alaska Division of Parks.
1975. Alaska recreation trail plan. 115 p., illus. Alaska Div. Parks, Anchorage.

KEYWORDS: Planning, trails and hiking, State parks.

157. Alaska Division of Parks.
1975. Denali State Park: a master plan. 49 p., illus. Alaska Div. Parks, Anchorage.

This master plan establishes guidelines for the development of the Denali State Park area. The foundation of the plan is an analysis of the park's environmental conditions and the current and anticipated trends of recreational use and demand on the area. In addition to providing development guidelines, this document serves as a tool for management. The specific conceptual purposes of the plan are to provide a description of the natural resources of the park; to describe the socioeconomic elements affecting the area, including recreational demands; to provide a land-use plan which will provide for optimum recreational use of the area commensurate with preserving its recreational values; to provide a staged implementation schedule for the development plan; and to identify the programs and staffing necessary for the proper maintenance and operation of the park.

KEYWORDS: Planning, State parks.

158. Alaska Environmental Group, The.
1972. Chugach State Park: a summary development guide for the park. 43 p. Alaska Div. Parks, Anchorage.

The report summarizes the long-range planning efforts by the Alaska Environmental Group for management of the 512,000-acre Chugach State Park in south-central Alaska, largest of the State Park System. The report is in three sections: an inventory of environmental factors, recommendations for recreational land use, and guidelines for implementation of the plan.

KEYWORDS: Planning, State parks.

159. Alaska Environmental Group, The.
1972. Kachemak Bay State Park. 32 p., illus. Alaska Div. Parks, Anchorage.

This report provides a summary of the planning effort by the authors for Kachemak State Park, on the Kenai Peninsula. The material is in three sections: an environmental inventory of the park, a summary of recommended uses, and guidelines for implementation of the plans. The report includes black-and-white photos, color maps, and tables.

KEYWORDS: Planning, State parks.

160. Alaska Environmental Group, The.
1972. A summary development guide for the Lake Louise study area. 42 p., illus. Alaska Div. Parks, Anchorage.

The purpose of this study was to identify certain threatened environmental values in the Lake Louise study area (in the Copper River Basin, about 180 miles northeast of Anchorage), and to develop a plan for future use of the area, compatible with principles of wise use. The report presents an inventory of the natural and cultural environment of the area, summarizes recommended land and water use, and suggests guidelines for implementation of its recommendations.

KEYWORDS: State parks, planning.

161. Alaska Housing Authority.
1959. Comprehensive plan, Ketchikan, Alaska. [n.p.] Alaska Housing Auth., Anchorage.

Five pages are on parks and recreation.

KEYWORDS: Planning, municipal parks.

162. Alaska Housing Authority.
1959. Seward comprehensive plan. [n.p.] Alaska Housing Auth., Anchorage.

The plan includes sections on parks, recreation facilities, and tourism.

KEYWORDS: Planning, municipal parks, tourism, sites and facilities.

163. Alaska Housing Authority.
1964. Skagway comprehensive plan. 53 p. Alaska Housing Auth., Anchorage.

Pages 37-38 are on parks and recreation.

KEYWORDS: Planning, municipal parks.

164. Alaska Housing Authority.
1965. Ketchikan and the Gateway Borough comprehensive plan. 117 p. Alaska Housing Auth., Anchorage.

Pages 20-22 are on tourism, and pages 78-79 and 98-99 are on parks and recreation.

KEYWORDS: Planning, municipal parks, tourism.

165. Alaska Housing Authority.
1966. Bristol Bay Borough comprehensive development plan. 175 p. Alaska Housing Auth., Anchorage.

Pages 67-77 are on tourism and recreation.

KEYWORDS: Planning, municipal parks, tourism.

166. Alaska Housing Authority.
1966. Greater Sitka Borough comprehensive development plan. 140 p. Alaska Housing Auth., Anchorage.

Pages 52-55 and 99-103 are on tourism and recreation.

KEYWORDS: Planning, municipal parks, tourism.

167. Alaska Housing Authority.
1966. Petersburg comprehensive development plan. 134 p. Alaska Housing Auth., Anchorage.

Part of page 95 is on parks, and pages 44-47 are on tourism.

KEYWORDS: Planning, municipal parks, tourism.

168. Alaska Housing Authority.
1967. Palmer comprehensive development plan. 79 p. Alaska Housing Auth., Anchorage.

Pages 33-35 are on parks and public open spaces.

KEYWORDS: Planning, municipal parks.

169. Alaska Housing Authority.
1968. Matanuska-Susitna Borough comprehensive development plan, phase I: survey and analysis. p. 141-215, illus. Alaska Housing Auth., Anchorage.

Pages 141-173 are on tourism. The plan contains references and a bibliography.

KEYWORDS: Municipal parks, planning, tourism.

170. Alaska Housing Authority.
1968. Wrangell comprehensive development plan. 164 p. Alaska Housing Auth., Anchorage.

Pages 55-69 are on tourism. Pages 125-126 are on parks and recreation.

KEYWORDS: Planning, municipal parks, tourism.

171. Anchorage Parks and Recreation Department.
[n.d.] Five year recreation and capital improvement program, 1966-71. [n.p.] Anchorage Parks and Recreation Dep.

KEYWORDS: Sites and facilities, municipal parks, planning, administration.

172. Clark-Coleman and Associates.
1959. Fairbanks comprehensive plan. 77 p. Alaska Housing Auth., Anchorage.

Pages 43-45 are on parks and recreation.

KEYWORDS: Municipal parks, planning.

173. Scott, G. Robert.
1971. Captain Cook Recreation Area: master plan report. 22 p., illus. Alaska Div. Parks, Anchorage.

The purpose of the study is to provide a master plan which will present the criteria for the development of the Captain Cook Recreation Area. The discussion includes analyses of the site as a whole, special problems and recommended treatments along with the various facilities for optimum development of the park, including camping, boating, canoeing, hiking, organized game areas, and winter sports such as cross-country skiing and snowmobiling. The project was not yet funded at the time the report was published. The document contains tables and maps.

KEYWORDS: Planning, State parks.

174. Tryck, Nyman and Hayes.
1968. Kodiak Island Borough comprehensive plan, 1968-1999. 320 p. Kodiak Isl. Borough.

KEYWORDS: Use projections, sites and facilities, planning, municipal parks, administration.

175. U.S. Department of Agriculture, Forest Service.
1972. South Tongass multiple use plan: special units. (Semifinal draft.) 90 p., illus. U.S. Dep. Agric. For. Serv., South Tongass Natl. For.

This preliminary plan divides the South Tongass into 41 special geographical units. Each unit is described briefly in terms of its geographical features and the current status of its management. Public comments and conflicts are identified for each unit, management alternatives are outlined, and future management direction is recommended, often on the basis of public input.

KEYWORDS: Land-use planning, National Forests, management, administration, planning.

176. U.S. Department of Agriculture, Forest Service, Chugach National Forest.
1972. Small boat recreation study and short term development plan for upper Prince William Sound. 53 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

The purpose of the plan is to develop key locations which will serve as convenient bases from which the boater can pursue his particular form of recreation. Nine proposed improvements in these key areas would involve expenditure of $111,000. An extensive appendix contains full-color photos and maps of the Prince William Sound area, weather information, and engineering designs for boat tieups.

KEYWORDS: Sites and facilities, boating, land-use planning, National Forests, planning, lakes and waterways, administration.

177. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1969. Izembek National Wildlife Range, Alaska, master plan. 25 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Portland, Oreg.

KEYWORDS: Wildlife refuges and ranges, fish and wildlife, land classification, administration, planning, hunting and fishing.

178. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1971. Arctic National Wildlife Range: master plan. 37 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Anchorage.

The goal of the plan is to keep the Arctic National Wildlife Range in its primitive condition. Objectives are to limit use of the Range by man, to provide access primarily by airplane and boat, to limit construction of roads and trails as much as possible, and to convert existing buildings along the coast and at Peters Lake to field stations and shelters. This publication is directed at the interested layman and is illustrated with photographs.

KEYWORDS: Land-use planning, Brooks Range, wildlife refuges and ranges, hunting and fishing, administration, planning, management, fish and wildlife.

179. U.S. Department of the Interior, National Park Service.
1955. A recreation program for Alaska. Volume 2 of part 2, Community and territorial recreation, Alaska recreation survey. 102 p., illus. U.S. Dep. Inter. Natl. Park Serv.

This is the fourth section of the Alaska Recreation Survey, conducted by the National Park Service during the 1950's. It details an administrative program for implementation by the Territory of Alaska. The eventuality of statehood is implicit in the plan. Included is a narrative survey of Alaska's contemporary recreation situation, resources and needs, and recommendations for pertinent territorial legislation, implementation of the program, land acquisition by the Territory for recreation purposes, and appropriate utilization of Federal aid. There is a brief discussion of the economic value of recreation resource development, followed by specific recommendations for facilities to be provided by the new territorial recreation administration. The bulk of the publication is an inventory of recreation areas, most of them along existing Alaskan highways. The survey is illustrated with photographs and charts; tables are included.

KEYWORDS: Sites and facilities, recreation inventories, planning, municipal parks, State parks, administration, land classification, laws and regulations.

180. U.S. Department of the Interior, National Park Service.
1971. A master plan: Katmai National Monument, Alaska. (Prelim. working draft.) 43 p., illus. U.S. Dep. Inter. Natl. Park Serv., Seattle.

Katmai National Monument is comprised of 2,792,137 acres (4,363 square miles) of largely wilderness land. The goal of the National Park Service's master plan is to preserve as much of this area as possible in its wilderness state for study and the enjoyment of visitors. The plan emphasizes visitor access to and accommodations in and around the National Monument. Water and air access are primary within the Monument. The plan designates 10 small areas for primary, secondary, and tertiary development of use nodes. Use projections extend to the year 2020. The Park Service proposes that the greater portion of Katmai National Monument land be classified as Primitive Area. Included in the plan are numerous maps, an appendix containing the management statement and objectives for Katmai National Monument, a summary of environmental factors, factors affecting environment and use, and pertinent legislation.

KEYWORDS: National Parks and Monuments, sites and facilities, land classification, land-use planning, use projections, planning, Wilderness and Primitive Areas.

181. Wyller, Killewich, VanDoren, and Hazard.
1973. Battery Point Recreation Area: master development plan. 47 p., illus. Alaska Div. Parks, Anchorage.

The Battery Point Recreation Area Master Development Plan proposes a means by which the 2,954.43-acre park may be developed to meet the needs of Alaska citizens from all parts of the State, provide for and attract visitors from outside Alaska, and protect the rights and interests of local residents. The Battery Point plan proposes that the park area should be multipurpose--providing for the development of trails ranging from those designed for the novice or elderly to those for the experienced hiker. The plan proposes camping and picnicking facilities which are high on the list of needs for the southeast Alaska region and which can be provided in the Battery Point area. Finally, the plan emphasizes interpretation and understanding of the history of the area. A three-phase development program is presented as a logical means by which the plan may be implemented.

KEYWORDS: Planning, State parks.

182. Wyller, Killewich, VanDoren, [and] Hazard.
1973. Fort Abercrombie Historic Site: master development plan, 33 p., illus. Alaska Div. Parks, Anchorage.

The development plan for Fort Abercrombie Historic Site proposes a historical theme. The fundamental aim of the plan is to provide at least for stabilization of the Fort and, to the extent permitted by available funds, the restoration of its more significant parts. Development of this site can provide outdoor recreation opportunities for the citizens of Alaska and can also provide excellent recreation experiences for the growing numbers of visitors to Alaska. The first phase of development is largely restricted to minimum improvements required to make the site initially usable and to stabilize the Fort remnants. The second phase proposes to make essential physical improvements to the Fort and to the area generally, and to acquire additional land. The third phase would provide for full restoration of the area, additional creature comforts, and protective facilities and services to prevent wanton destruction.

KEYWORDS: Planning, State parks, historical and cultural heritage.

D. POLICY DOCUMENTS

183. Alman, R. K.
1969. Maintenance and operation standards, Alaska State Park System. 22 p., Alaska Div. Lands, Anchorage.

KEYWORDS: State parks, management, administration.

184. Conservation Foundation, The.
1961. A policy study of outdoor recreation potential in Alaska. 141 p. The Conservation Foundation, New York.

This research report was prepared for the U.S. Outdoor Recreation Resources Review Commission.

KEYWORDS: Land-use planning, land classification, administration, use projections, planning, tourism.

185. Greater Anchorage Area Borough Planning Commission.
1972. Parks, recreation and open space: standards, policies and guidelines for development for the greater Anchorage area. 115 p., illus. Greater Anchorage Area Borough Plann. Dep., Tech. Serv. Div., Anchorage, Alaska.

KEYWORDS: Administration, municipal parks, sites and facilities.

186. Saroff, Jerome R.
1967. Alaska recreation and government policies. 143 p., illus. Fed. Field Comm. Dev. Plann. Alaska, Anchorage.

The study prescribes future government policy to maximize Alaska's recreation resources, with emphasis on integration of Federal, State, and local recreation programs. The committee used a systems approach to analyze the recreation situation in Alaska and offer solutions to problems and needs. Solutions offered reflect the committee's desire to break out of the "demand survey" approach to recreation planning, and to substitute the "development" approach, which would insure that the agencies involved anticipate the needs of the public rather than simply attempt to keep up with those needs. Multiple use guidelines are rejected in favor of a "priority use" philosophy. A Bureau of the Budget could coordinate the activities of all the agencies concerned with implementing recreation policy. Recreation and access are interdependent; thus, one of the major problems facing the implementation of effective recreation resource policy has been the lack of ongoing coordination between the State recreation and highway agencies. The solution would be for the Federal Highway Administration to see that the intent of Federal guidelines is followed by State highway and recreation agencies from the inception of a given project. Modes of transportation (air, water, highway) must be fused into an integral system. An alternative to the present organization of recreation resources would be a graduated hierarchy of facilities, to include wilderness and dispersed and centralized facilities (developed campgrounds near major population concentrations); the liabilities of this approach would be its complexity and expense. The report includes tables and a bibliography.

KEYWORDS: Planning, tourism, access, administration.

187. U.S. Department of Agriculture, Forest Service.
1971. Multiple use management guide for the Alaska region. U.S. Dep. Agric. For. Serv., FSH 1212.4, 65 p., illus. Juneau.

KEYWORDS: Management, land-use planning, National Forests, administration.

III. Historical and Cultural Material

188. Ackerman, Robert E. (ed.) and others.
1970. Ethnohistory in southwestern Alaska and southern Yukon: method and content. Univ. Press Ky., Stud. Anthropol. 7, 311 p., illus. Lexington.

KEYWORDS: Historical and cultural heritage.

189. Alaska Division of Parks [Office of History and Archaeology].
1975. Alaska heritage resource survey: index. 175 p. Alaska Div. Parks [Anchorage].

This is the computer printout index to "Alaska's Plan for Management and Conservation of Heritage Resources, 1973-1983: Volume 2, the Inventory" (191).

KEYWORDS: Recreation inventories, historical and cultural heritage.

190. Alaska Division of Parks, Office of History and Archaeology.
1975. Alaska's heritage resources, 1973-1983: volume 3, 1975-1976, the annual preservation program. 4th ed. 86 p., illus. Alaska Div. Parks, Anchorage.

Volume 3 is a status report on the existing State historical preservation effort, a discussion of long-range planning, and a projection of needs during the fiscal years 1976, 1977, and 1978. This volume of the statewide historic preservation plan is revised annually.

KEYWORDS: Historical and cultural heritage.

191. Alaska Division of Parks, Office of History and Archaeology.
1975. Alaska's plan for management and conservation of heritage resources, 1973-1983: volume 2, the inventory. 29 p., illus. Alaska Div. Parks, Anchorage.

The statewide historic preservation plan for Alaska, of which this is volume 2, is prepared in three sections. "The Inventory" describes the purpose and scope of the statewide inventory of historic and archeological locations; it also presents, in an electronic data processing format, the State's historic and prehistoric resources by thematic association, location, State planning region, and ownership (see 189). This volume summarizes the content of the inventory by discussing the thematic framework used to classify and compare Alaska's historic resources and explains the format and capabilities of computer reports reflecting the inventory. Appendixes present the inventory in selected arrangements.

KEYWORDS: Historical and cultural heritage.

192. DeLaguna, Frederica.
1956. Chugach prehistory: The archaeology of Prince William Sound, Alaska. Univ. Wash. Publ. Anthropol. 13, 289 p., illus. Seattle.

KEYWORDS: Historical and cultural heritage.

193. DeLaguna, Frederica, Francis A. Riddell, and others.
1964. Archaeology of the Yakutat Bay area. Bur. Am. Ethnol. Bull. 192, 245 p., illus. Smithson. Inst., Washington, D.C.

KEYWORDS: Historical and cultural heritage.

194. Endicott, Wendell.
1928. Adventures in Alaska and along the trail. 344 p. Frederick A. Stokes Co., New York.

KEYWORDS: Historical and cultural heritage, scenery.

195. Hussey, John A.
1971. Embattled Katmai: a history of Katmai National Monument. 457 p., illus. U.S. Dep. Inter. Natl. Park Serv. Off. Hist. and Hist. Archit., San Francisco, Calif.

Included are an extensive bibliography, black-and-white photos, historic maps, and schematic drawings.

KEYWORDS: Historical and cultural heritage, National Parks and Monuments.

196. Jackson, Shelton, D. D.
1880. Alaska and missions on the north Pacific coast. 400 p., illus. Dodd, Mead and Co., New York.

KEYWORDS: Historical and cultural heritage.

197. Karr, H. W. Seton.
1887. Shores and alps of Alaska. 248 p., illus. A. C. McClurg and Co., London and Chicago.

KEYWORDS: Historical and cultural heritage, scenery.

198. Miller, Polly.
1968. Lost heritage of Alaska. 289 p., illus. World Publ. Co., Cleveland and New York.

KEYWORDS: Historical and cultural heritage.

199. Muir, John.
1915. Travels in Alaska. 327 p., illus. Houghton Mifflin Co., Boston and New York.

KEYWORDS: Historical and cultural heritage, scenery, wilderness values.

200. Pearson, Grant H.
1952. History of Mt. McKinley National Park. 124 p. U.S. Dep. Inter. Natl. Park Serv., Anchorage.

KEYWORDS: Historical and cultural heritage, National Parks and Monuments.

201. U.S. Department of the Interior, Geological Survey.
1899. Maps and description of routes of exploration in Alaska in 1898. 138 p., illus. Gov. Print. Off., Washington, D.C.

KEYWORDS: Historical and cultural heritage.

202. U.S. Department of the Interior, National Park Service.
1961. Alaska history: 1641-1910. Natl. Surv. Hist. Sites Build., Theme 21: Political and military affairs, 1865-1910, spec. study. 222 p., illus. U.S. Dep. Inter. Natl. Park Serv., Washington, D.C.

This report contains 138 pages of history, 69 pages on the survey of historical sites and buildings, and a 13-page bibliography.

KEYWORDS: Historical and cultural heritage.

203. U.S. Department of the Interior, National Park Service.
1962. Alaska aboriginal culture. Natl. Surv. Hist. Sites Build., Theme 16: Indigenous peoples and cultures, spec. study. 171 p., illus. U.S. Dep. Inter. Natl. Park Serv.

This exhaustive archeological study inventories and describes the important Alaskan sites discovered by 1962. It contains an extensive bibliography and black-and-white photographs.

KEYWORDS: Historical and cultural heritage.

204. Wolfe, Linnie Marsh (ed.).
1938. John of the mountains: the unpublished journals of John Muir. 459 p., illus. Houghton Mifflin Co., Boston.

KEYWORDS: Historical and cultural heritage.

IV. Bibliographic Material

205. Alaska Northwest Publishing Company.
1971. Alaska Magazine's book catalog. 36 p., illus. Alaska Northwest Publ. Co., Anchorage.

KEYWORDS: Bibliography.

206. Alaska Northwest Publishing Company.
1973. Subject index to Alaska Magazine, 1935-1972. 121 p. Alaska Northwest Publ. Co., Anchorage.

KEYWORDS: Bibliography.

207. Hoffman, Joseph E., Jr.
1970. Alaska outdoor recreation references. 39 p. Univ. Alaska Inst. Bus., Econ. Gov. Res., College [Fairbanks].

This list provides planners, researchers, and students with an index of outdoor recreation publications on Alaska. Information provided includes author, subject matter, and publisher.

KEYWORDS: Bibliography.

208. Lada-Mocarski, Valerian.
1969. Bibliography of books on Alaska published before 1868. 567 p. Yale Univ. Press, New Haven and London.

KEYWORDS: Bibliography, historical and cultural heritage.

209. Tourville, Elsie A.
1974. Alaska: a bibliography, 1570-1970, with subject index. 738 p. G. K. Hall, Boston.

This publication cites books and pamphlets in many languages and on many subjects, including fiction, history, geology, anthropology, meteorology, travel, conservation, hunting, fishing, zoology, mineralogy, etc. It contains no government publications except those published in trade book form.

KEYWORDS: Bibliography.

V. Popular Material

210. Alaska Division of Lands.
1967. Camping under the midnight sun. 42 p., illus. Alaska Travel Div., Juneau.

This booklet lists and describes campgrounds administered by the Alaska State Division of Lands, situated along 13 major Alaskan highways. It includes maps, black-and-white photos, and an introductory section of general information for recreationists.

KEYWORDS: Sites and facilities, highways and roads, camping, recreation inventories, access.

211. Alaska Division of Lands.
1968. The Chilkoot trail: a guide to the goldrush trail of '98. 20 p., illus. Alaska Div. Lands, Juneau.

KEYWORDS: Historical and cultural heritage, sites and facilities, trails and hiking, tourism.

212. Alaska Division of Lands.
[n.d.] Juneau trail system, Juneau, Alaska. 5 p., illus. Alaska Div. Lands, Juneau.

KEYWORDS: Sites and facilities, historical and cultural heritage, municipal parks, trails and hiking.

213. Alaska Planning Office.
1941. General information regarding Territory of Alaska. 176 p., illus. Off. Gov., Juneau.

This early survey offers general information about Alaska for the interested layman.

KEYWORDS: Sites and facilities, historical and cultural heritage, tourism, scenery, Wilderness and Primitive Areas.

214. Anderson, Roy.
1946. Alaska's recreational riches. 76 p. Alaska Dev. Board, Juneau.

This inventory of Alaska's recreational resources provides information to potential travelers and settlers. The Alaska Development Board has gleaned facts from Federal, Territory, and local government agencies territory-wide to compile information on transportation, National Parks and Monuments, big game hunting, fishing, sightseeing, camping, and many other forms of recreation. The bulk of the survey describes 300 places to go in Alaska, including urban, rural, and wilderness points of interest.

KEYWORDS: Sites and facilities, access, tourism, recreation inventories, scenery.

215. Boehm, William D.
1975. Glacier Bay. 134 p., illus. Alaska Northwest Publ. Co., Anchorage.

This book is a full-color pictorial survey of the scenic wonders of Glacier Bay National Monument, seen through the eyes of the author-photographer. It includes a 14- by 20-inch insert map of the region.

KEYWORDS: Scenery.

216. Brooks, Paul.
1962. Alaska: the last frontier. Atlantic 210(3):73-78, illus.

Alaska offers an "opportunity to practice the principles of conservation that we have learned elsewhere at such appalling cost." The author describes the spectacular features of the Alaska landscape as he experienced them.

KEYWORDS: State parks, wilderness values, scenery, Wilderness and Primitive Areas.

217. Brooks, Paul.
1965. Paul Brooks replies. Atlantic 216(1):59.

The author responds to Ernest Gruening's "The Plot To Strangle Alaska" (224). The Rampart Dam would destroy the habitats of waterfowl and moose, disrupt the salmon runs on the Yukon River, displace native villages, and generate more hydroelectric power than Alaska is capable of using in the forseeable future. Other locations are better suited to Alaska's needs for inexpensive power. In the author's opinion, Senator Gruening did not respond to Mr. Brooks' original arguments in opposition to the Rampart project. (See "The Plot To Drown Alaska" (218).)

KEYWORDS: Wilderness and Primitive Areas, wilderness values, economic development, Rampart Dam.

218. Brooks, Paul.
1965. The plot to drown Alaska. Atlantic 215(5):53-59, illus.

The proposed Rampart Dam would create a huge lake that would drown the Yukon Flats, destroy the habitats of numerous waterfowl, and displace several Native villages. The cost of the dam would far outweigh the benefits. Cheap hydroelectric power could as well be created by a series of smaller dams at other sites. The author believes the project to be a make-work measure for Alaska's underemployed residents, an attempt to bolster Alaska's sagging economy without consideration for the long-range impact on its more enduring resources. The Rampart Dam would not provide the benefits its supporters claim it will.

KEYWORDS: Wilderness and Primitive Areas, economic development, Rampart Dam, fish and wildlife, wilderness values.

219. Brown, Dale, and the Editors of Time-Life Books.
1972. Wild Alaska. The American Wilderness/Time-Life Books. 179 p., illus. Time, Inc., New York.

This publication contains a narrative survey of the physical and esthetic qualities of Alaska's wilderness and is illustrated with full-color photographs and maps. The style is descriptive, aimed at the interested layman. Included is a short bibliography.

KEYWORDS: Wilderness and Primitive Areas, fish and wildlife, wilderness values, scenery.

220. Canadian Government Travel Bureau.
[n.d.] Alaska Highway: road to Yukon adventure. 40 p., illus. Gov. Travel Bur., Ottawa, Can.

KEYWORDS: Highways and roads, sites and facilities, scenery, tourism.

221. Cooley, Richard A.
1967. Alaska: a challenge in conservation. 170 p., illus. Univ. Wis. Press, Madison, Milwaukee, and London.

The national attitude toward land--the space itself--has changed in the last century from a conquering one to a conserving one. This "changing concept of land--the growing emphasis on the esthetics of land use--has deep and far-reaching implications, and it is important that Alaska's future be conceived, her lands and resources weighed, in the perspective of a new national vision." In 1959, the Federal Government provided for a total of 104 million acres to be selected by the new Alaska State government over the following 25 years, to be managed and used for the benefit of the State. The challenge that faced the new Alaska State Division of Lands in its selection, classification, and management of this vast land grant was to integrate both the need for these land resources in the development of a viable State economy and the necessity to conserve these resources for esthetic purposes--to preserve the unique frontier character of Alaska. The author surveys the efforts of Alaska's land agencies to evolve effective land-use policy and briefly analyzes the most serious obstacles to successful land-use planning in Alaska. The publication includes tables, maps, and a bibliography.

KEYWORDS: Land-use planning, land classification, wilderness values, economic development, management, Wilderness and Primitive Areas.

222. Garret, W. E.
1965. Alaska's Marine Highway. Natl. Geogr. 127(6):776-819, illus.

KEYWORDS: National Forests, Alaska Marine Highway System, scenery.

223. Gruening, Ernest.
1963. Lonely wonders of Katmai. Natl. Geogr. 123(6):800-831.

Describes the scenic resources of Katmai National Monument in words and pictures.

KEYWORDS: Scenery.

224. Gruening, Ernest.
1965. The plot to strangle Alaska. Atlantic 216(1):56-59.

Senator Gruening responds to Paul Brooks' article, "The Plot To Drown Alaska" (218). The Rampart Dam would be economically advantageous to Alaska and would not jeopardize its wildlife resource. Conservationists who oppose the project are placing the needs of wildlife above the economic needs of people and are attempting to retard Alaska's economic development.

KEYWORDS: Wilderness and Primitive Areas, wilderness values, economic development, Rampart Dam.

225. Hakala, D. R.
[n.d.] Interpreting the Tongass National Forest via the Alaska Marine Highway. 83 p., illus. U.S. Dep. Agric. For. Serv., Alaska Reg., Juneau.

KEYWORDS: Alaska Marine Highway System, National Forests, scenery.

226. Hauser, William E. (ed.).
1967. Thirty hikes in Alaska: Western Chugach, Talkeetna, Kenai. 70 p., illus. Mountaineering Club of Alaska and Seattle Mountaineers, Anchorage and Seattle.

KEYWORDS: Sites and facilities, Kenai Peninsula, trails and hiking, National Forests, wilderness values, scenery, access.

227. Hession, Jack.
1972. Showdown in Alaska. Sierra Club Bull. 57(2):5-8, illus.

Under the Alaska Native Claims Settlement Act of 1971, the Secretary of the Interior has the option of selecting and withdrawing up to 80 million acres from previously unreserved Bureau of Land Management lands for inclusion in the National Park and National Forest Systems. The State of Alaska is in competition with the U.S. Department of the Interior for some of these lands. The Secretary must act swiftly to insure that they do not fall to State and private interests, which would open them to commercial development and the possible destruction of irreplaceable wilderness resources.

KEYWORDS: Land classification, Wilderness and Primitive Areas, economic development, wilderness values, Alaska Native Claims Settlement Act.

228. Hunter, Celia.
1970. Alaskan wilderness: going, going--gone? Natl. Parks and Conserv. Mag. 44(278):11-15.

The author feels that principles that guided the proposal for the Wrangell Mountains National Scenic Area, worked out by the Bureaus of Outdoor Recreation and Land Management, should be extended to all of Alaska to prevent such degradation of scenic and recreation values as has occurred in Mount McKinley National Park as a result of mining activities there.

KEYWORDS: Wilderness values, economic development.

229. Krell, Dorothy (ed.).
1974. Alaska. 208 p., illus. Lane Mag. and Book Co., Menlo Park, Calif.

This hard cover pictorial survey of Alaska's scenic resources is splendidly illustrated with full-color and black-and-white photographs, drawings, and maps.

KEYWORDS: Scenery.

230. Laycock, George.
1971. Alaska: The embattled frontier. 205 p., illus. Houghton Mifflin Co., Boston, in cooperation with Natl. Audubon Soc.

KEYWORDS: Wilderness values.

231. McClean, Herbert E.
1965. Jet age camping. Am. For. 71(7):16-17, 59, illus.

KEYWORDS: Tourism, sites and facilities, camping, National Forests.

232. McCloskey, Maxine E. (ed.)
1970. Wilderness: the edge of knowledge. 266 p. Sierra Club, San Francisco and New York.

This collection of papers was presented at the Sierra Club's Eleventh Biennial Wilderness Conference (San Francisco, Calif., March 14, 1969). Thirty-six conservationists, biologists, government officials, and wilderness travelers give wide-ranging views of the wilderness value of Alaska and on wilderness and wildlife preservation generally. Included are some of the earliest responses to the announcement of the proposed Alaskan oil pipeline. Appendixes include the endangered species list, the Endangered Species Conservation Act of 1969, Regulations on Public Outdoors Recreation Use of Bureau of Land Management lands, National Conservation Bill of Rights, etc.

KEYWORDS: Wilderness and Primitive Areas, laws and regulations, land classification, wilderness values.

233. Marshall, Robert.
1970. Alaska wilderness: exploring the Central Brooks Range. 2d ed. 167 p., illus. Univ. Calif. Press, Berkeley. (Originally published as "Arctic Wilderness.")

This is an account of Robert Marshall's travels by foot, boat, and dogsled into Wilderness Areas north of the Arctic Circle. It is a personal description of the Alaska wilderness in the Brooks Range in the 1930's. Black-and-white photographs are included.

KEYWORDS: Wilderness and Primitive Areas, Brooks Range, trails and hiking, wilderness values, historical and cultural heritage, scenery.

234. Murphy, Robert.
1968. Wild sanctuaries. 286 p., illus. E. P. Dutton and Co., Inc., New York.

KEYWORDS: Fish and wildlife, Wilderness and Primitive Areas, wildlife refuges and ranges, wilderness values.

235. Post, Austin, and Edward R. LaChapelle.
1971. Glacier ice. Univ. Wash. Press, Seattle and London.

KEYWORDS: Scenery.

236. Rearden, Jim.
1968. State of Alaska's guides. Alaska Sportsman 34(11):6-10, 52-53, illus.

Nonresident big game hunters pay Alaska's guides an estimated $5 million annually. Big game hunting in Alaska became very fashionable in the early 1960's; this led to increasing abuses of the big game resource. The Alaska State Legislature has attempted to respond to these abuses as they arise, with specific laws and regulations covering the licensing and practice of guides and hunters. One basic factor is responsible for the abuse of Alaska's big game resource: there is a change in the Alaskan hunter--he is younger, more pressed for time, and more goal-oriented than in the past. Consequently, his guide is encouraged to provide him with a speedy kill or as many kills as possible. Despite these disturbing trends, most of Alaska's guides are conscientious, ethical, and responsible. Hunters should request references from prospective guides.

KEYWORDS: Laws and regulations, hunting and fishing, wilderness values.

237. Rearden, Jim.
1972. Our last wilderness revisited, part 1: pied pipers of Alaska. Outdoor Life 149(3):59-61, 204, 206, 208, illus.

The human and physical impact of the trans-Alaska pipeline on the Brooks Range environment has already begun. More and more people visit the Range, hunting laws and regulations are ignored, illegal roads are cut into Wilderness Areas, and wildlife habitats and migration routes are disrupted. The promise of immediate financial rewards has overshadowed the need for careful planning to minimize the destruction of large parts of the Alaska environment by the oil industry.

KEYWORDS: Brooks Range, Wilderness and Primitive Areas, laws and regulations, hunting and fishing, wilderness values, fish and wildlife.

238. Rearden, Jim.
1972. Our last wilderness revisited, part 2: the Brooks Range today. Outdoor Life 149(4):64-67, 124, 126, 128, 130, 132, illus.

Alaska's wilderness is its most enduring valuable resource. The State of Alaska has not lived up to its responsibility to see that the development and exploitation of Alaskan oil are not at the expense of her wilderness. This second of two articles on the Brooks Range contains a vivid account of the author's Dall-ram hunting expedition.

KEYWORDS: Wilderness and Primitive Areas, Brooks Range, hunting and fishing, wilderness values, wildlife refuges and ranges, fish and wildlife.

239. Rogers, George W.
1960. Alaska in transition: the southeast region. 384 p., illus. The Johns Hopkins Press, Baltimore.

KEYWORDS: Economic development, economic analysis.

240. Rogers, George W.
1962. The future of Alaska: economic consequences of statehood. 311 p., illus. The Johns Hopkins Press, Baltimore.

The book includes a major discussion of the future development of Alaska's natural resources. Alaska's most valuable resource is its wilderness.

KEYWORDS: Use projections, fish and wildlife, Wilderness and Primitive Areas, tourism, economic development, wilderness values.

241. Schafer, Martin F.
1968. The Alaska travel story. 10th Annu. Conf. West. Counc. Travel Res. Proc. 1968: 125-134. [Univ. Utah, Salt Lake City.]

KEYWORDS: Tourism.

242. U.S. Department of Agriculture, Forest Service.
1969. Alaska wilderness in perspective. 7 p. U.S. Dep. Agric. For. Serv., Juneau.

The need for the wilderness resource must be considered together with the demand for other resources--timber, minerals, etc. In the weighing process, the need for wilderness must be analyzed separately to establish its relative value.

KEYWORDS: Land classification, land-use planning, Wilderness and Primitive Areas, administration.

243. U.S. Department of Agriculture, Forest Service.
1971. National Forest facts: Alaska region, 1971. 19 p. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Fire and fire control, land classification, National Forests.

244. U.S. Department of Agriculture, Forest Service.
[n.d.] Granite Fiords wilderness study area, Tongass National Forest, Alaska. 4 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Wilderness and Primitive Areas, scenery.

245. U.S. Department of Agriculture, Forest Service.
[n.d.] Mendenhall recreation area. 8 p. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Use statistics, sites and facilities, use projections, National Forests.

246. U.S. Department of Agriculture, Forest Service.
[n.d.] Nellie Juan wilderness study area, Chugach National Forest, Alaska. 4 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Wilderness and Primitive Areas, scenery.

247. U.S. Department of Agriculture, Forest Service.
[n.d.] Tracy Arm wilderness study area, Tongass National Forest, Alaska. 4 p., illus. U.S. Dep. Agric. For. Serv., Juneau.

KEYWORDS: Wilderness and Primitive Areas, land classification, National Forests.

248. U.S. Department of the Interior.
1967. Natural resources of Alaska. 76 p., illus. U.S. Dep. Inter., Off. Secr., Off. Inf., Washington, D.C.

This publication is a general survey for the interested layman. It covers history, mineral resources, fish and wildlife, outdoor recreation, water and power resources, and forests and includes brief descriptions of current programs of the Federal natural resource agencies.

KEYWORDS: Historical and cultural heritage, State parks, fish and wildlife, National Parks and Monuments, wildlife refuges and ranges, sites and facilities, scenery, National Forests.

249. U.S. Department of the Interior, Bureau of Outdoor Recreation.
1966. Guides to outdoor recreation areas and facilities. 36 p., illus. U.S. Dep. Inter. Bur. Outdoor Recreation, Washington, D.C.

KEYWORDS: Sites and facilities, recreation inventories.

250. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1967. Wilderness study area: Bogoslof Island, Alaska. 8 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Kenai, Alaska.

KEYWORDS: Wilderness and Primitive Areas, fish and wildlife, wildlife refuges and ranges, scenery, hunting and fishing.

251. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1967. Wilderness study areas: St. Lazaria, Hazy Islands, Forrester Island National Wildlife Refuges, Alaska. 8 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Anchorage.

KEYWORDS: Wilderness and Primitive Areas, fish and wildlife, wildlife refuges and ranges, scenery.

252. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1967. Wilderness study area: Tuxedni National Wildlife Refuge, Alaska. 8 p., illus. U.S. Dep. Inter. Bur. Sport Fish. and Wildl., Kenai, Alaska.

KEYWORDS: Wilderness and Primitive Areas, fish and wildlife, wildlife refuges and ranges, scenery, hunting and fishing.

253. U.S. Department of the Interior, Bureau of Sport Fisheries and Wildlife.
1972. To have and to hold. 15 p., illus. Gov. Print. Off., Washington, D.C.

KEYWORDS: Fish and wildlife, wilderness values.

254. U.S. Department of the Interior, Division of Territories and Island Possessions.
1946. Alaska. 65 p., illus. Gov. Print. Off., Washington, D.C.

KEYWORDS: Fish and wildlife, wildlife refuges and ranges, historical and cultural heritage, tourism, laws and regulations, scenery.

255. U.S. Department of the Interior, Office of Territories.
1952. Mid-century Alaska. 170 p., illus. Gov. Print. Off., Washington, D.C.

KEYWORDS: National Parks and Monuments, tourism, historical and cultural heritage, laws and regulations.

256. Washburn, Bradford.
1971. A tourist guide to Mt. McKinley. 79 p., illus. Alaska Publ. Co., Anchorage.

KEYWORDS: Tourism, National Parks and Monuments, scenery.

257. Wilderness Society, The.
1973. Alaska: where 40 Yellowstones are threatened. Wilderness Rep. 10(2):1-8, illus.

This publication outlines the Wilderness Society's proposals for classification of the lands withdrawn and reserved by the Secretary of the Interior in accordance with the Alaska Native Claims Settlement Act. It includes a map and brief descriptions of 22 areas the Wilderness Society recommends for inclusion in the National Park and Wildlife Refuge Systems.

KEYWORDS: Wilderness values, land classification, Alaska Native Claims Settlement Act.

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The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

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2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

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The FOREST SERVICE of the U.S. Department of Agriculture is dedicated to the principle of multiple use management of the Nation's forest resources for sustained yields of wood, water, forage, wildlife, and recreation. Through forestry research, cooperation with the States and private forest owners, and management of the National Forests and National Grasslands, it strives — as directed by Congress — to provide increasingly greater service to a growing Nation.

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USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-51
1976

PHOTO SERIES FOR QUANTIFYING FOREST RESIDUES IN THE:

COASTAL DOUGLAS-FIR—HEMLOCK TYPE
COASTAL DOUGLAS-FIR—HARDWOOD TYPE

WAYNE G. MAXWELL
FRANKLIN R. WARD

A COOPERATIVE
PUBLICATION
PUBLISHED BY:

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE
PORTLAND, OREGON

ABSTRACT

Six series of photographs display different forest residue loading levels, by size classes, for areas of like timber type and cutting practice.

Information with each photo includes measured weights, volumes and other residue data, information about the timber stand and harvest or thinning actions, and fuel ratings.

These photo series provide a fast and easy-to-use means for quantifying and describing existing and expected residues.

KEYWORDS: Residue (forest), residue management fuel (waste wood), slash (Douglas-fir--hemlock) (Douglas-fir--hardwood), management (forest), forest residues estimation.

COOPERATIVE ACKNOWLEDGMENT

This publication was developed by the Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, in cooperation with the Bureau of Land Management, U.S. Department of the Interior; Washington State Department of Natural Resources; State of Oregon Forestry Department; and U.S. Forest Service, Region 6, to serve the needs of forest land managers in the Pacific Northwest.

LIST OF PLANT SPECIES CITED

cherry	*Prunus* spp.
chinkapin	*Castanopsis* spp.
Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
lodgepole pine	*Pinus contorta* Dougl.
madrone	*Arbutus* spp.
ponderosa pine	*Pinus ponderosa* Laws.
Port-Orford-cedar	*Chamaecyparis lawsoniana* (A. Murr.) Parl.
red fir	*Abies* spp.
tanoak	*Lithocarpus densiflorus* (Hook. & Arn.) Rehd.
vine maple	*Acer circinatum* Pursh
western hemlock	*Tsuga heterophylla* (Raf.) Sarg.
western redcedar	*Thuja plicata* Donn
western white pine	*Pinus monticola* Dougl.
white fir	*Abies concolor* (Gord. & Glend.) Lindl.

METRIC CONVERSIONS

1 acre = 0.4047 hectare
2.471 acres = 1 hectare
1 cubic foot = 0.02832 cubic meter
35.31 cubic feet = 1 cubic meter
1 foot = 0.3048 meter
3.281 feet = 1 meter
1 inch = 2.54 centimeters
0.3937 inch = 1 centimeter
1 ton (short) = 0.907 ton (metric)
1.102 tons (short) = 1 ton (metric)

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WHAT ARE THESE PHOTO SERIES?

These photo series are arrays of photos, with each array showing different residue loading levels generated from like timber types and cutting practices. Each photo is supplemented with information which includes:

- Measured quantities by size classes, average depth, ground area covered, and other residue data.
- Harvesting or thinning information.
- Fuel ratings.

Thus, the series provide a basis for quantifying and describing existing and expected residue loadings on other areas and serve as a communication link between users.

WHY ARE THEY NEEDED?

Timber harvesting, silvicultural practices, and land clearing operations generate forest residues on nearly 1.5 million acres annually in Washington and Oregon; the trend toward more partial cutting and less clearcutting will increase acres cutover in subsequent years if the volume cut remains constant.

Although some residues are beneficial for such purposes as nutrient cycling, soil protection, wildlife cover, and microclimate effect, excessive residues adversely affect the forest environment in many ways. Much of the forest contains residues in undetermined but excessive quantities from the standpoints of resource use, protection, and management. To reduce residues to a level considered desirable, estimates are needed on quantities that now exist or will be created by some activity.

Inventory techniques, such as the planar intersect method, are very useful when a high degree of accuracy is needed but are time consuming and costly to apply extensively. Photo series can be used to make fast, easy, and inexpensive quantifications of residue, adequate for most management needs.

There has been no way for all resource disciplines to become readily familiar with residue volumes and descriptions so that they can make quantitative inputs to residue management. Likewise, because fuel rating systems are specialized and subjective, they too are not readily adapted to other environmental components. These deficiencies can be overcome with the photo series.

HOW CAN THEY BE USED?

Inventory of Down Residue

Loadings in various residue size classes, average residue depth, and ground area covered are characteristics that are visible in the photographs; hence, users can estimate any of these characteristics on an area being inventoried by comparing them with the photos as follows:

1. Observe each characteristic of the residue on the ground (e. g., 3. 1- to 9-inch loading).
2. Select a photo which nearly matches, or photos that bracket, the observed characteristic.
3. Obtain the quantitative value for the characteristic being estimated from the data sheet accompanying the selected photo (or interpolate a value between photos).

These steps are repeated for each characteristic desired. If the general area being inventoried has zones of obvious differences in residue loading, the user should consider making separate determinations for each zone, which can then be weighted and cumulated for the whole area.

Residue characteristics not distinguishable in the photographs are duff and litter depth, proportion of sound residue by species, and proportion rotted. If values for these characteristics are desired in an inventory, they must be derived from independent sampling or observations.

Inventory information can be used by land managers to (1) evaluate impacts residues have on various aspects of forest management, (2) identify areas of unacceptable residue loading, (3) identify priority areas for treatment, (4) estimate amount of utilizable material, and (5) predict fire behavior characteristics.

Determination of Desired Residue Level

Land management objectives can be more nearly achieved if a team of appropriate specialists can participate in specifying residues which should remain on site after completion of a cutting activity. Individuals helping with these determinations can study the photo series to recognize the appearance of various quantities and distributions of residue. With this knowledge, each individual can describe in quantitative terms the residue he believes should be retained to meet environmental concerns and goals of his particular specialty. The group can then use the photo series as a communication tool to resolve differences in arriving at a desired level.

After treatment, the degree to which objectives were achieved can be judged by comparing observed posttreatment loading with the desired level description.

Prediction of Residues From Planned Cutting and Residue Changes From Treatments

Photo series are a rudimentary aid for predicting amounts of residue from cutting and residue changes from treatments. Many factors, such as condition of timber stand, topography, logging method, and utilization intensity, affect the volume of resulting residues, so users should bear in mind that these series depict only a few of the possible combinations.

To predict residue volumes from planned cutting, the user compares timber volume and size information from cutting plans with this kind of information in the photo series. Selecting a photo series level or levels with similar stand characteristics, the user refers to data sheet loadings, considers factors which differ from the photo series situations, and quantifies the loading expected.

Predicted loadings can be used to support changes in cutting and removal actions and to plan appropriate treatments.

To predict residue changes from treatments, the user studies the treated and untreated levels in the photo series to gain knowledge of relative changes or reductions affected by sample treatments. Then, comparing residue inventory or preharvest prediction information with levels in the series, the user determines the change a specific treatment may produce.

Predicted change in residue from treatments can aid in (1) identifying treatments that will reduce residues to the desired level, (2) selecting the most cost-effective treatments, and (3) estimating tons that will be consumed by fire. Improved accuracy in estimating tons consumed by fire will increase reliability of particulate and chemical compound emission calculations.

HOW WERE THEY DEVELOPED?

Areas photographed for these series were selected to show typical residue loading variations resulting from commonly applied harvest and cultural practices in major vegetative types of the coastal Pacific Northwest. Photos were taken and data collected as follows:

1. Areas were photographed and the material in the photo area sampled in accordance with U.S. Forest Service national guidelines.[1]

2. Measurement technique was in accordance with the "Handbook for Inventorying Downed Woody Material."[2]

3. Timber stand, logging, and residue treatment information was obtained from timber sale or project records in field offices.

4. Forest Service Region 6 fuel types were assigned by a panel of Forest Service fuel specialists.[3]

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[1] USDA Forest Service. 1975. National fuel classification and inventory system, preliminary draft. 61 p., illus. Washington Office, Washington, D.C.

[2] Brown, James K. 1974. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p., illus. Intermt. For. and Range Exp. Stn., Ogden, Utah.

[3] USDA Forest Service Region 6. 1968. Guide for fuel type identification. 48 p., illus. Portland, Oreg.

HOW CAN THEY BE SUPPLEMENTED?

If users in the coastal Pacific Northwest find they have important local residue loadings which are not adequately represented, they can supplement these series or develop additional series by following procedures described in the referenced documents. The series in this publication may be usable, in total or in part, in appropriate vegetative types in other regions.

These series do not show residue loadings in stands undisturbed by cutting activities. Natural residue photo series may be developed in the future to aid in inventorying such areas.

A companion publication, containing photo series for use in ponderosa pine, ponderosa pine and associated species, and lodgepole pine types, will be published by the Pacific Northwest Forest and Range Experiment Station.

HOW ARE LEVELS IN THESE SERIES CODED?

The data for each level are presented on the page facing the photo. Facing picture and data pages have the same code for the residue situation shown. The code shows:

a. Order of rank from lightest loading to heaviest loading shown in the series of photographs.

b. Forest type, e.g., DF = Douglas-fir--hemlock, DFHD = Douglas-fir--hardwood.

c. Forest size class, where:

1 = <5-inch d.b.h.

2 = 5- to 11-inch d.b.h.

3 = 12- to 20-inch d.b.h.

4 = >20-inch d.b.h.

d. Cutting practice, where:

CC = clearcut

PC = partial cut (shelterwood, selection, overstory removal)

TH = precommercial thinning

Example: 1-DF-4-CC is the first photo in the series for Douglas-fir--hemlock, >20-inch diameter trees, after harvest by clearcutting.

DOUGLAS-FIR—HEMLOCK

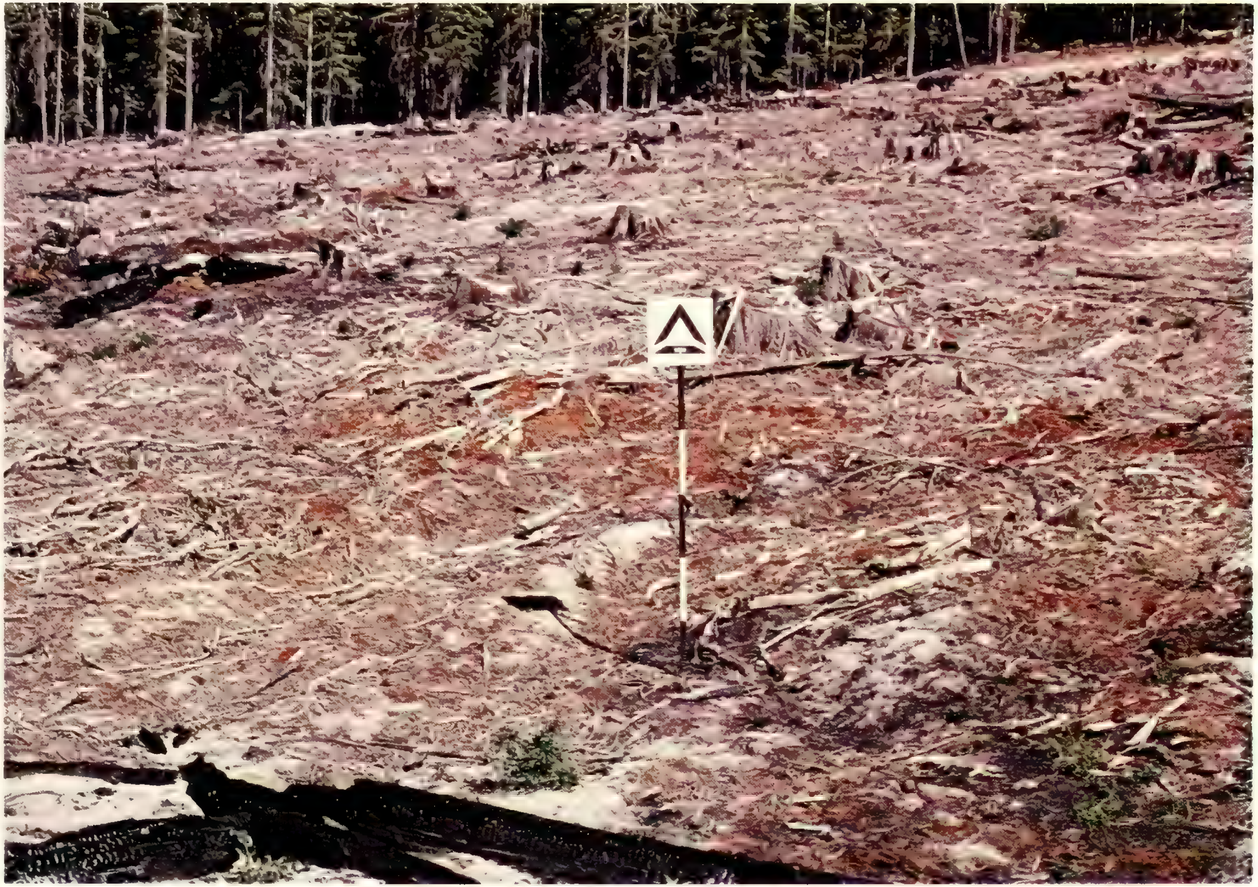
SIZE CLASS 4

CLEARCUT

A SERIES OF 10 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-DF-4-CC

DATA SHEET

Residue descriptive code 1-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.0	114
1.1-3.0	1.5	93
3.1-9.0	3.6	252
9.1-20.0	0	0
20.1+	0	0
Total	7.1	459

OTHER MEASUREMENTS

Average residue depth (feet) 0.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 52

Average duff and litter depth (inches) 1.9

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 81

white fir (percent) 16

other (percent) 3

Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 58

Net volume cruised (M fbm/acre) 54

Average stems/acre cut 55

Average d.b.h. of stems cut (inches) 24

Stand age (years) 200+

Cutting prescription Clearcut

Yarding method Tractor

Slash treatment Machine piled & burned

Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre

Stems remaining/acre

Basal area/acre before

Basal area/acre after

Average d.b.h. before (inches)

Average d.b.h. after (inches)

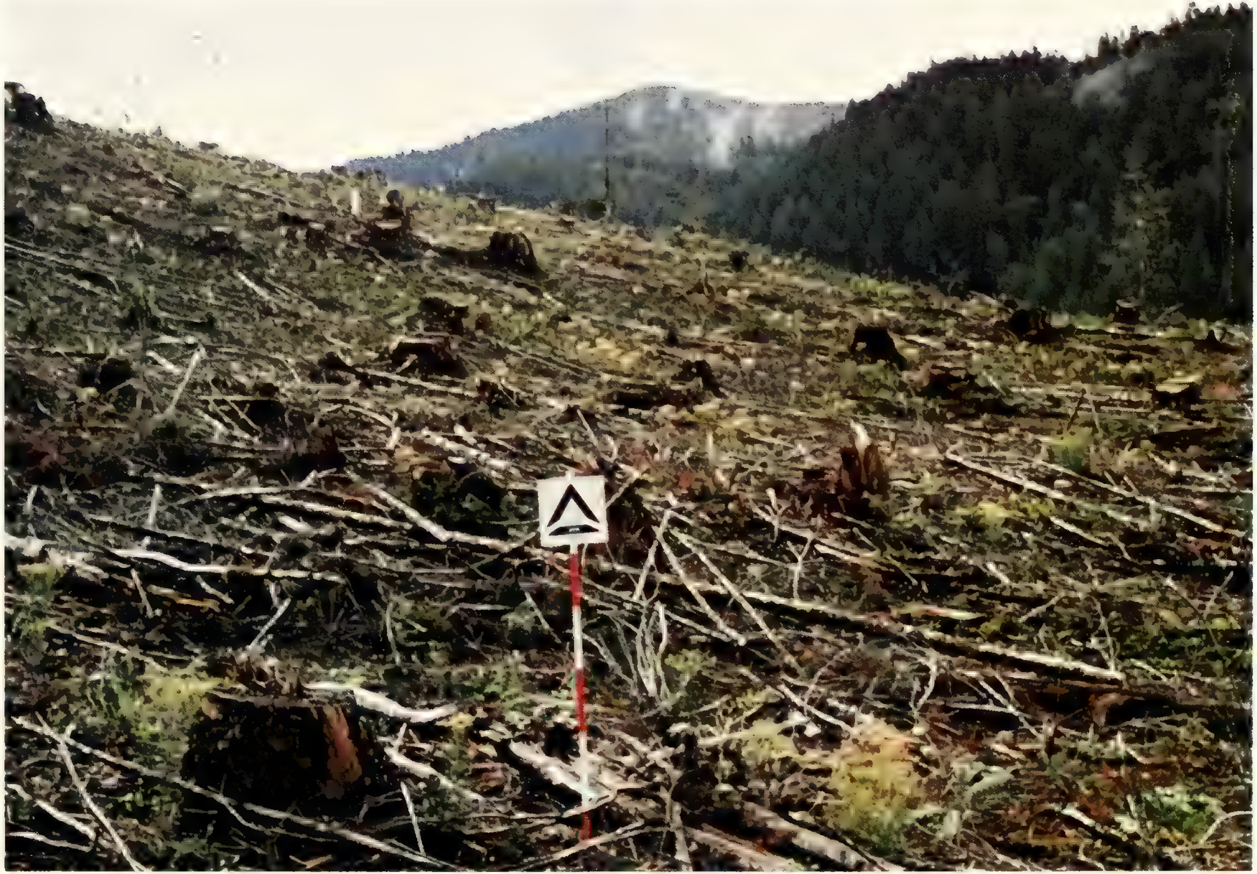
Thinning method

Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



2-DF-4-CC

DATA SHEET

Residue descriptive code 2-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.4	135
1.1-3.0	7.5	464
3.1-9.0	6.6	439
9.1-20.0	0.7	50
20.1+	0	0
Total	17.2	1,088

OTHER MEASUREMENTS

Average residue depth	(feet)	0.3
Ground area covered by residue 1/4-inch diameter and larger	(percent)	64
Average duff and litter depth	(inches)	2.3
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	16
vine maple	(percent)	5
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	79

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	72
Net volume cruised (M fbm/acre)	48
Average stems/acre cut	43
Average d.b.h. of stems cut (inches)	30
Stand age (years)	250+
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

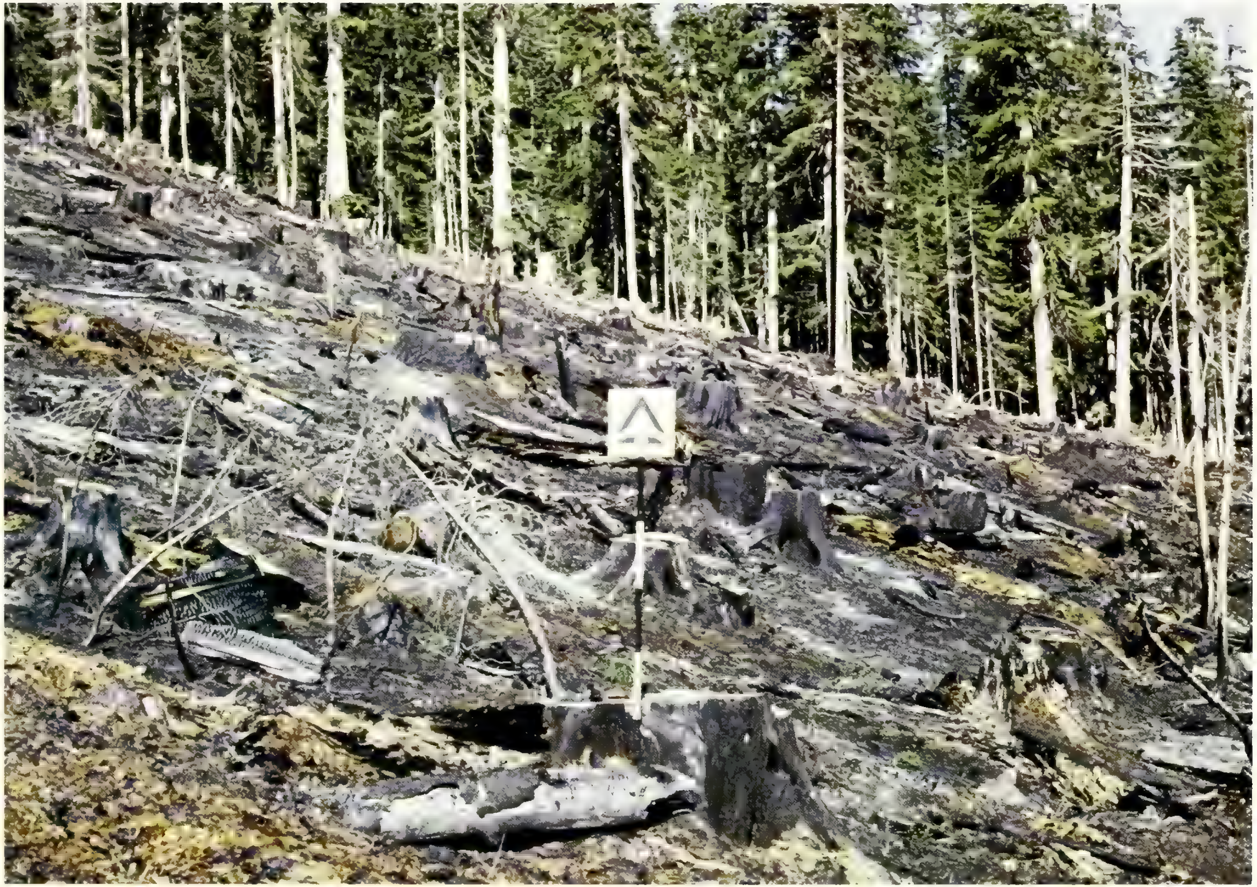
Stems cut/acre ____
Stems remaining/acre ____
Basal area/acre before ____
Basal area/acre after ____
Average d.b.h. before (inches) ____
Average d.b.h. after (inches) ____
Thinning method ____
Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS

*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end, and 10 feet in length.



3-DF-4-CC

DATA SHEET

Residue descriptive code 3-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.7	37
1.1-3.0	1.4	84
3.1-9.0	8.0	579
9.1-20.0	11.0	825
20.1+	7.0	460
Total	28.1	1,985

OTHER MEASUREMENTS

Average residue depth (feet) 0.2
Ground area covered by residue 1/4-inch diameter and larger (percent) 41
Average duff and litter depth (inches) 4.1
Sound residue 3.1-inch diameter and larger white fir (percent) 18
Douglas-fir (percent) 9
other (percent) 3
Rotted residue 3.1-inch diameter and larger (percent) 70

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 89
Net volume cruised (M fbm/acre) 58
Average stems/acre cut 70
Average d.b.h. of stems cut (inches) 29
Stand age (years) 350+
Cutting prescription Clearcut
Yarding method High-lead
Slash treatment YUM* & broadcast burned
Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS

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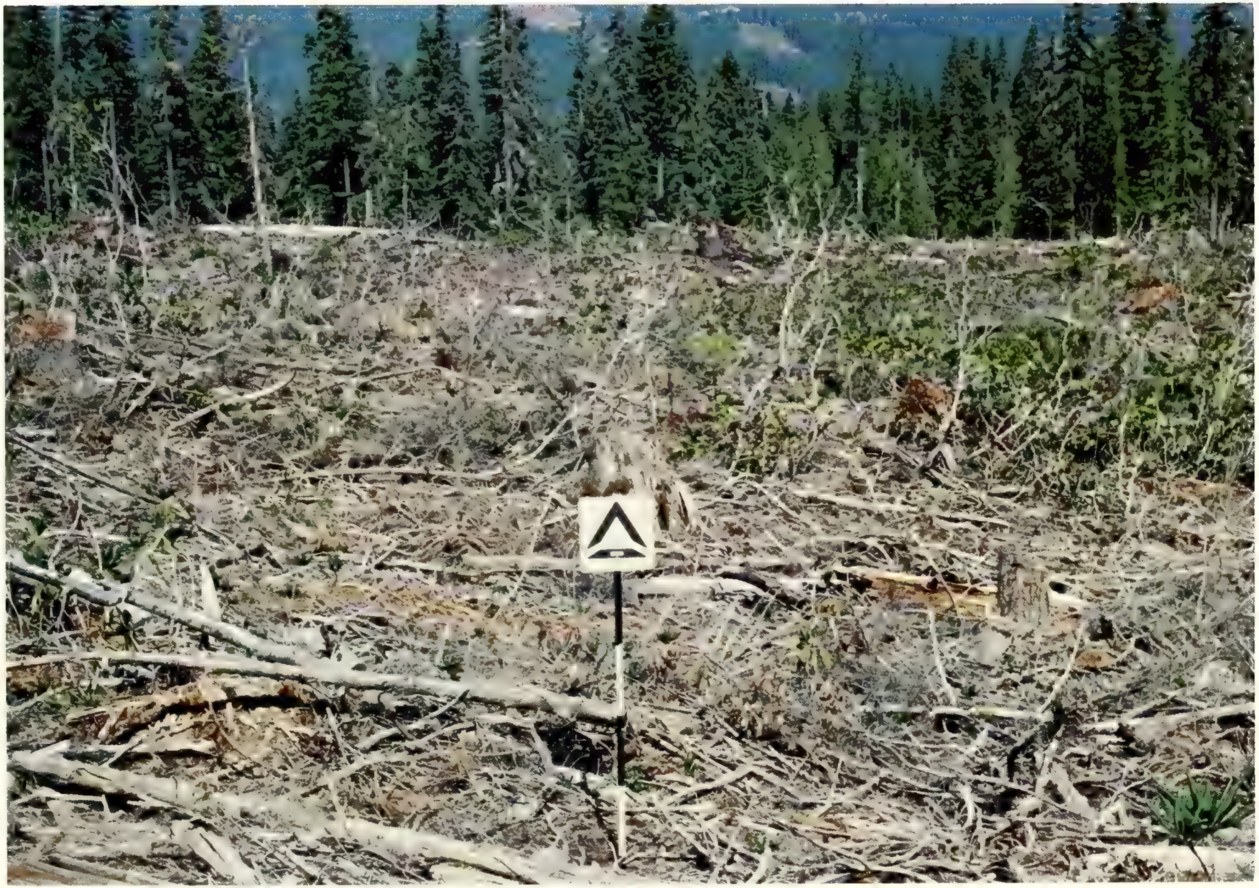
*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end and 10 feet in length.



4-DF-4-CC

DATA SHEET

Residue descriptive code 4-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	5.6	374
1.1-3.0	7.6	610
3.1-9.0	7.3	647
9.1-20.0	10.7	1,038
20.1+	5.8	615
Total	37.0	3,284

OTHER MEASUREMENTS

Average residue depth	(feet)	0.9
Ground area covered by residue 1/4-inch diameter and larger	(percent)	99
Average duff and litter depth	(inches)	7.1
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	14
western redcedar	(percent)	6
other	(percent)	4
Rotted residue 3.1-inch diameter and larger	(percent)	76

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	60
Net volume cruised (M fbm/acre)	29
Average stems/acre cut	38
Average d.b.h. of stems cut (inches)	34
Stand age (years)	250+
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

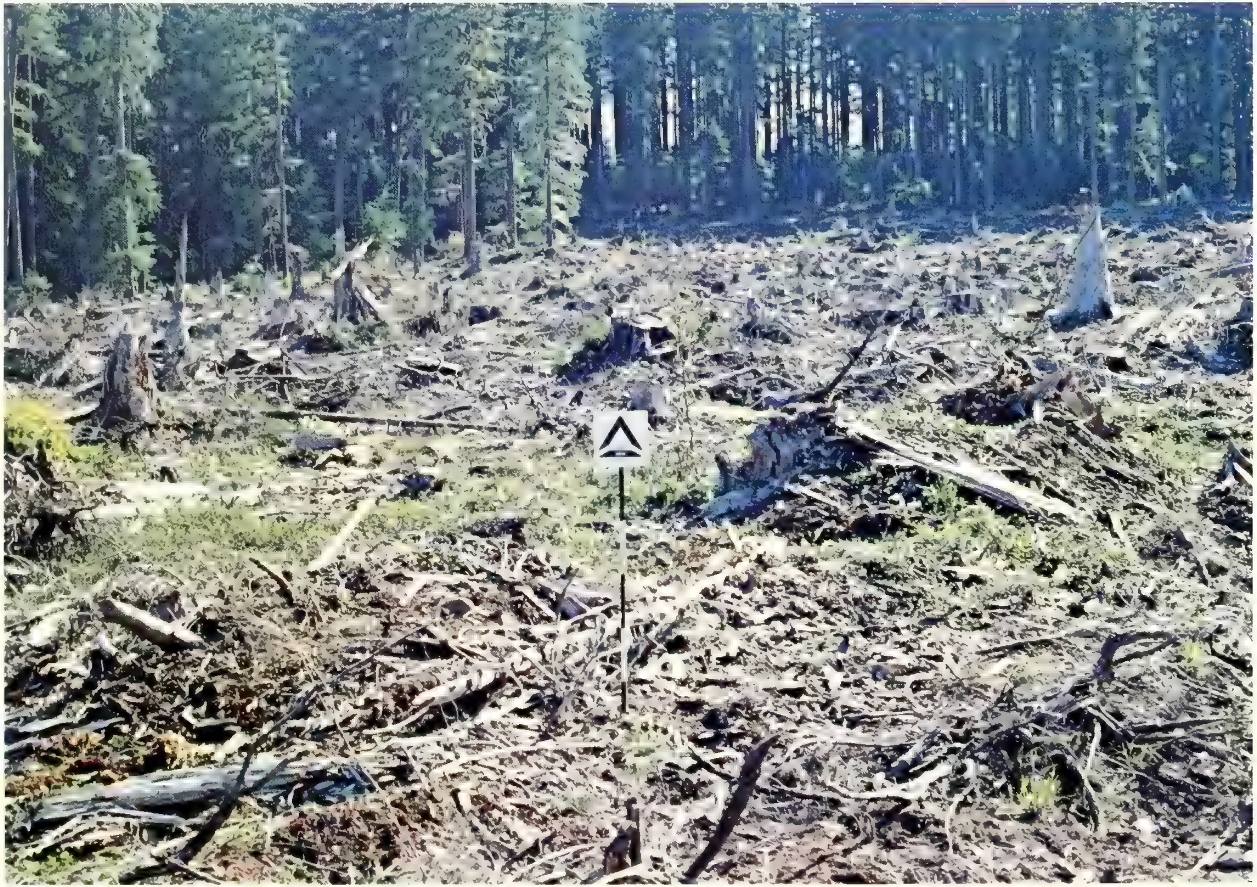
Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	MH

REMARKS

*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end and 10 feet in length.



5-DF-4-CC

DATA SHEET

Residue descriptive code 5-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.6	174
1.1-3.0	4.5	361
3.1-9.0	14.3	1,053
9.1-20.0	15.7	1,069
20.1+	8.3	573
Total	45.4	3,230

OTHER MEASUREMENTS

Average residue depth	(feet)	0.6
Ground area covered by residue 1/4-inch diameter and larger	(percent)	78
Average duff and litter depth	(inches)	3.3
Sound residue 3.1-inch diameter and larger western hemlock	(percent)	36
Douglas-fir	(percent)	19
other	(percent)	12
Rotted residue 3.1-inch diameter and larger	(percent)	33

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	84
Net volume cruised (M fbm/acre)	57
Average stems/acre cut	36
Average d.b.h. of stems cut (inches)	40
Stand age (years)	400
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	12

PRECOMMERCIAL THINNING INFORMATION

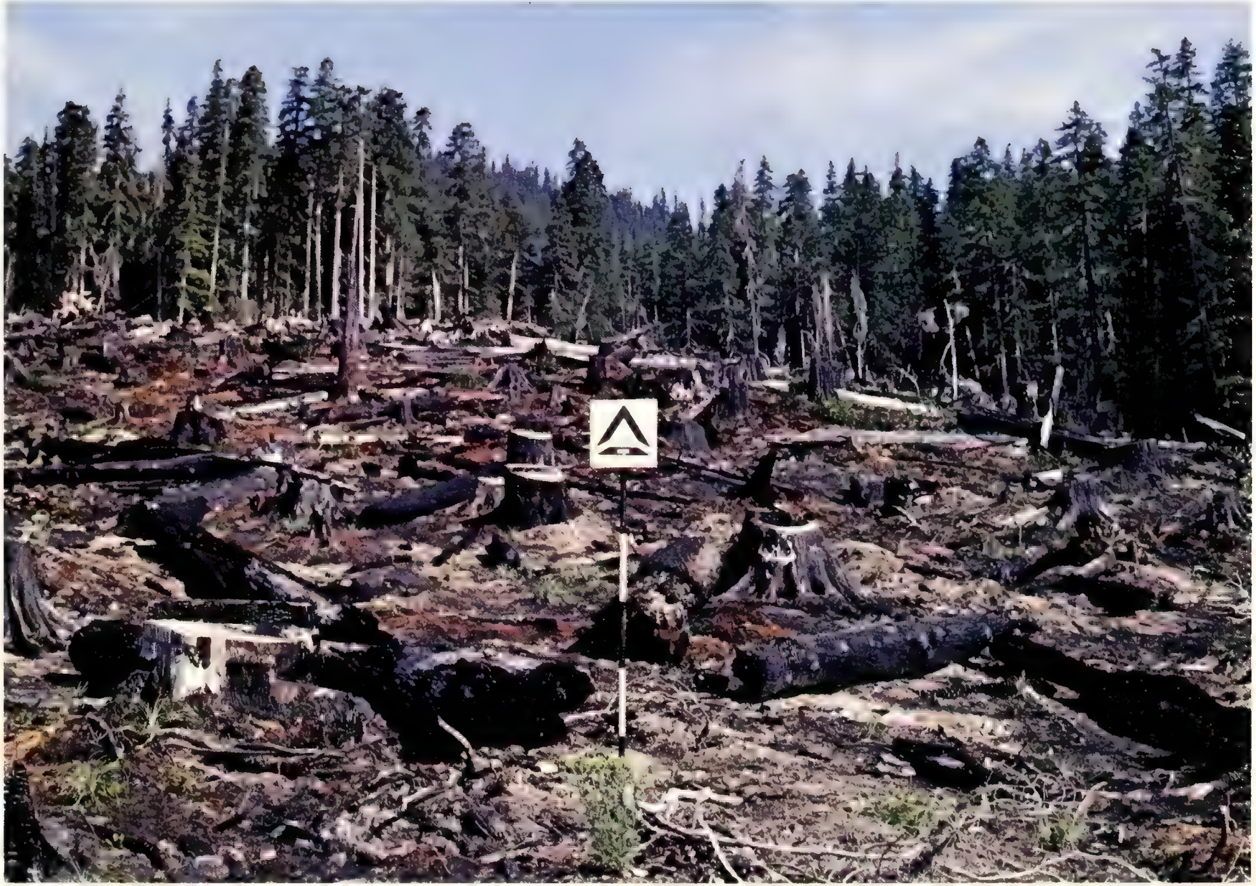
Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HM

REMARKS

*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end and 10 feet in length.



6-DF-4-CC

DATA SHEET

Residue descriptive code 6-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.5	29
1.1-3.0	0.4	25
3.1-9.0	7.0	514
9.1-20.0	25.1	1,683
20.1+	31.0	2,086
Total	64.0	4,337

OTHER MEASUREMENTS

Average residue depth (feet) 0.3

Ground area covered by residue 1/4-inch diameter and larger (percent) 45

Average duff and litter depth (inches) 2.1

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 45

western hemlock (percent) 6

other (percent) 5

Rotted residue 3.1-inch diameter and larger (percent) 44

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 93

Net volume cruised (M fbm/acre) 62

Average stems/acre cut 44

Average d.b.h. of stems cut (inches) 38

Stand age (years) 160+

Cutting prescription Clearcut

Yarding method High-lead

Slash treatment Fall broadcast burn

Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____

Stems remaining/acre ____

Basal area/acre before ____

Basal area/acre after ____

Average d.b.h. before (inches) ____

Average d.b.h. after (inches) ____

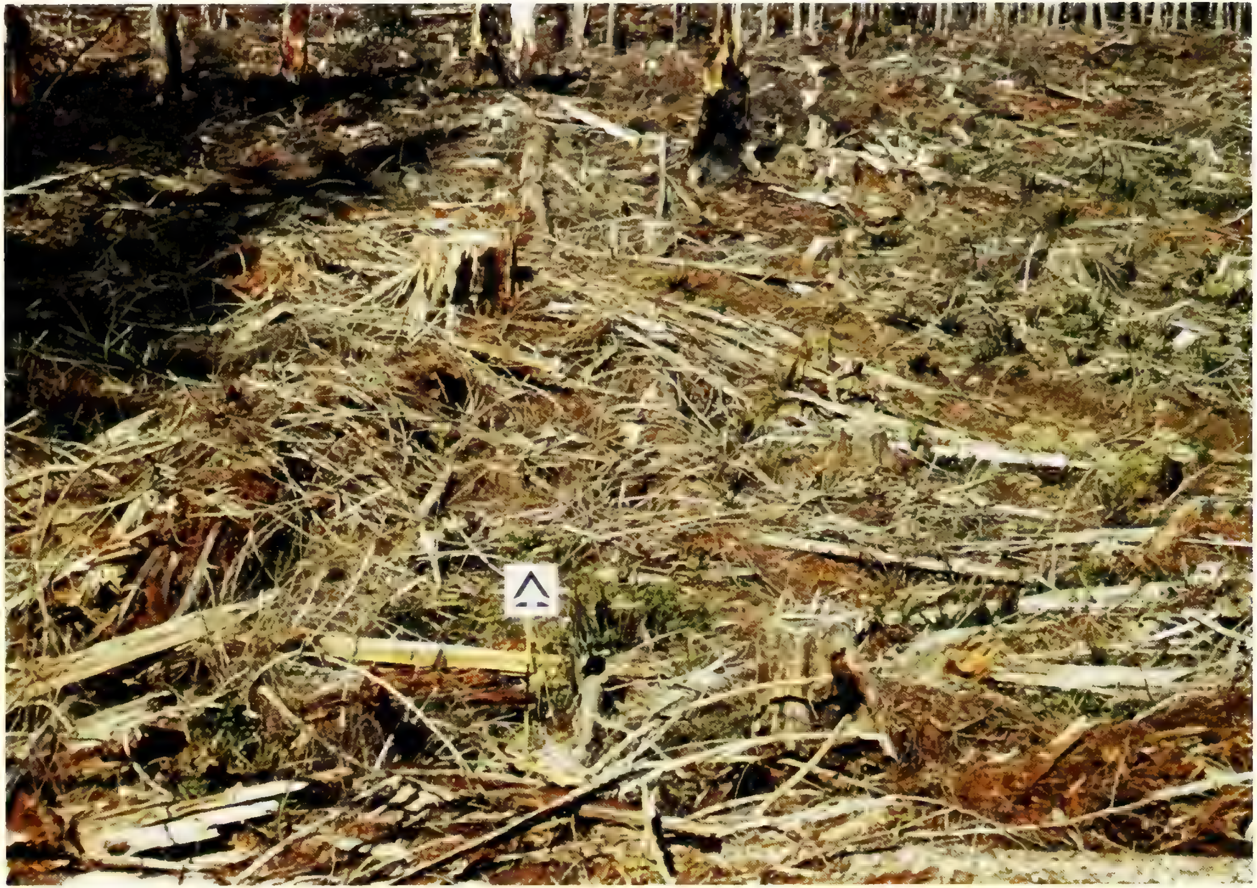
Thinning method ____

Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



7-DF-4-CC

DATA SHEET

Residue descriptive code 7-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	4.9	279
1.1-3.0	11.3	696
3.1-9.0	22.0	1,526
9.1-20.0	13.9	960
20.1+	45.0	3,005
Total	97.1	6,466

OTHER MEASUREMENTS

Average residue depth	(feet)	1.1
Ground area covered by residue 1/4-inch diameter and larger	(percent)	97
Average duff and litter depth	(inches)	7.9
Sound residue 3.1-inch diameter and larger western hemlock	(percent)	8
Douglas-fir	(percent)	4
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	88

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	48
Net volume cruised (M fbm/acre)	42
Average stems/acre cut	33
Average d.b.h. of stems cut (inches)	25
Stand age (years)	300+
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	<6

PRECOMMERCIAL THINNING INFORMATION

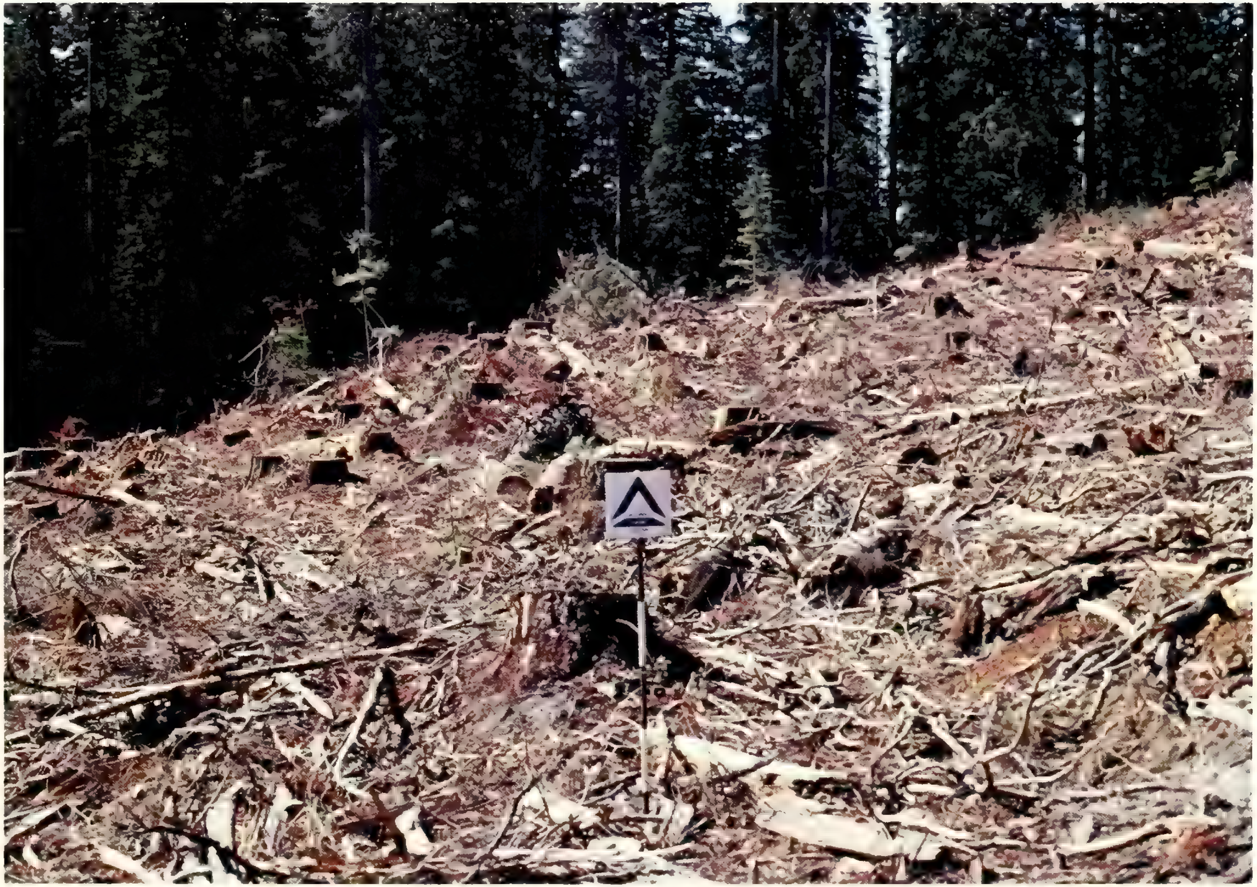
Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

*Required yarding unmerchantable material (YUM) down to 16 inches in diameter, small end and 10 feet in length.



8-DF-4-CC

DATA SHEET

Residue descriptive code 8-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	4.3	287
1.1-3.0	5.9	472
3.1-9.0	16.1	1,147
9.1-20.0	23.2	1,634
20.1+	54.9	3,777
Total	104.4	7,317

OTHER MEASUREMENTS

Average residue depth (feet) 1.0

Ground area covered by residue 1/4-inch diameter and larger (percent) 92

Average duff and litter depth (inches) 6.2

Sound residue 3.1-inch diameter and larger western hemlock (percent) 21

Douglas-fir (percent) 20

other (percent) 6

Rotted residue 3.1-inch diameter and larger (percent) 53

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 89

Net volume cruised (M fbm/acre) 58

Average stems/acre cut 44

Average d.b.h. of stems cut (inches) 42

Stand age (years) 350

Cutting prescription Clearcut

Yarding method High-lead

Slash treatment None

Period since cut or treatment (months) 1

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______

Stems remaining/acre ______

Basal area/acre before ______

Basal area/acre after ______

Average d.b.h. before (inches) ______

Average d.b.h. after (inches) ______

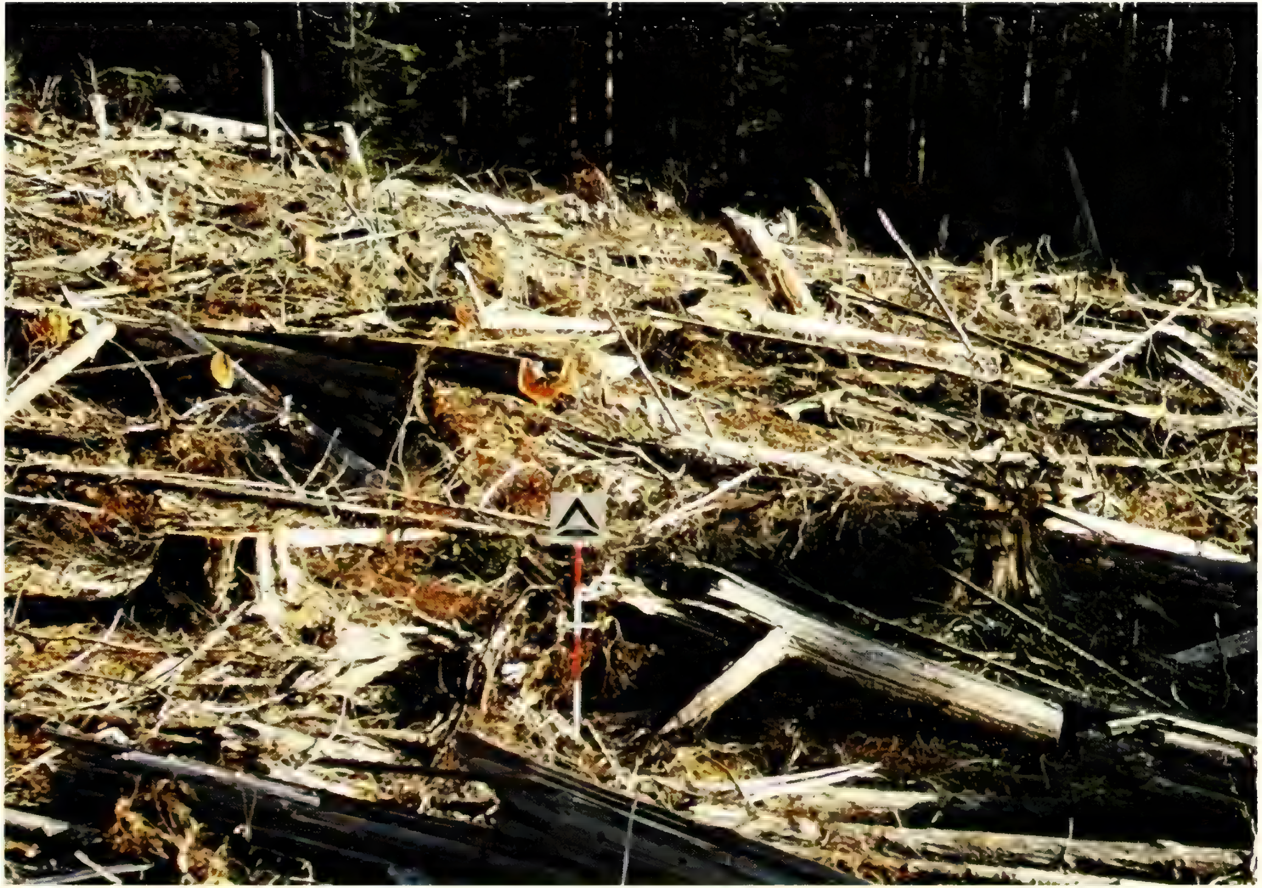
Thinning method ______

Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS



9-DF-4-CC

DATA SHEET

Residue descriptive code 9-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	4.8	275
1.1-3.0	8.4	518
3.1-9.0	33.8	2,505
9.1-20.0	52.1	3,989
20.1+	47.5	3,227
Total	146.6	10,514

OTHER MEASUREMENTS

Average residue depth		(feet)	1.4
Ground area covered by residue 1/4-inch diameter and larger		(percent)	100
Average duff and litter depth		(inches)	9.8
Sound residue 3.1-inch diameter and larger	Douglas-fir	(percent)	12
	western hemlock	(percent)	11
	other	(percent)	10
Rotted residue 3.1-inch diameter and larger		(percent)	67

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	79
Net volume cruised (M fbm/acre)	67
Average stems/acre cut	60
Average d.b.h. of stems cut (inches)	29
Stand age (years)	300+
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	None
Period since cut or treatment (months)	6

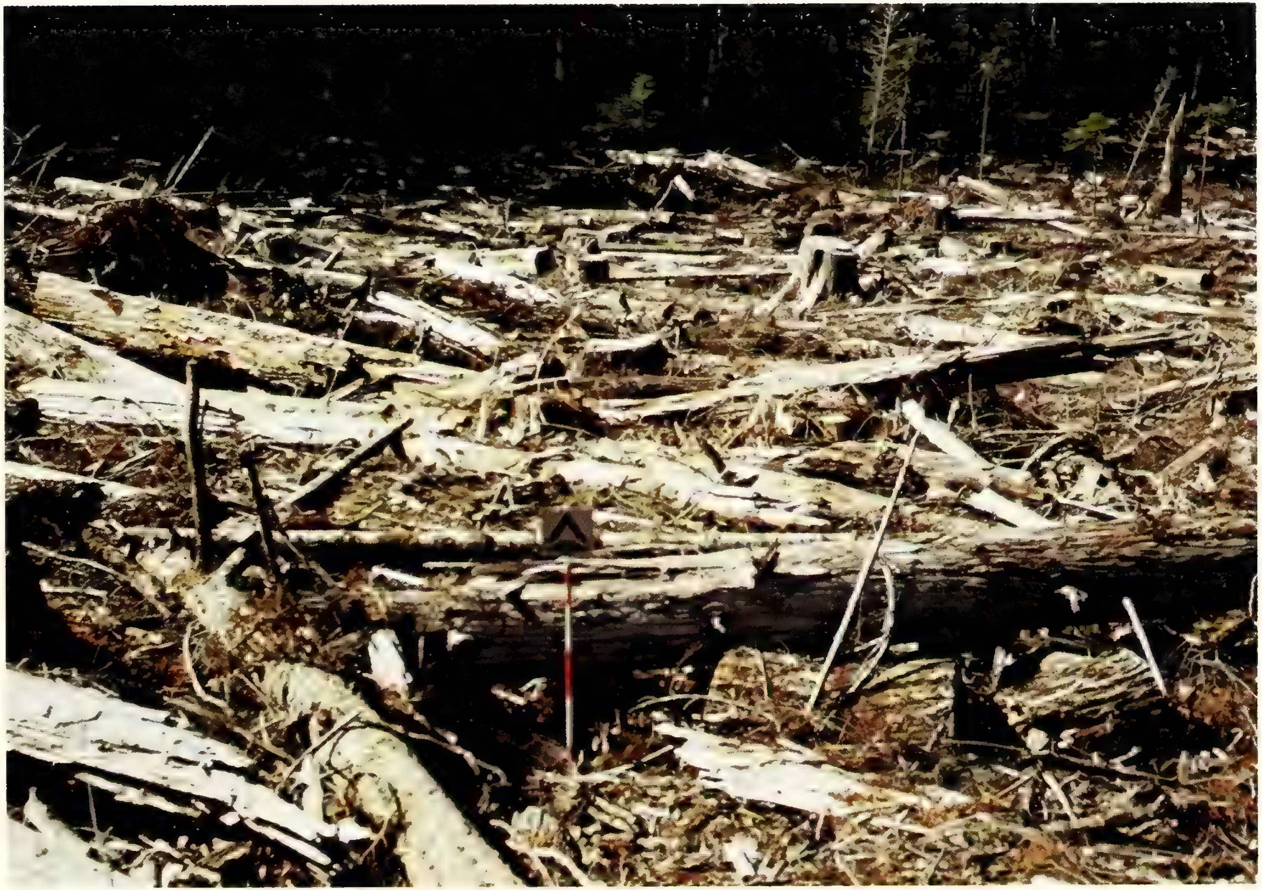
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification EE

REMARKS



10-DF-4-CC

DATA SHEET

Residue descriptive code 10-DF-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.6	206
1.1-3.0	11.0	678
3.1-9.0	18.5	1,348
9.1-20.0	30.3	2,152
20.1+	160.0	10,825
Total	223.4	15,209

OTHER MEASUREMENTS

Average residue depth (feet) 1.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 88

Average duff and litter depth (inches) 8.6

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 14

Pacific silver fir (percent) 2

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 84

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 131

Net volume cruised (M fbm/acre) 79

Average stems/acre cut 55

Average d.b.h. of stems cut (inches) 32

Stand age (years) 300+

Cutting prescription Clearcut

Yarding method High-lead

Slash treatment None

Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre

Stems remaining/acre

Basal area/acre before

Basal area/acre after

Average d.b.h. before (inches)

Average d.b.h. after (inches)

Thinning method

Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HE

REMARKS

DOUGLAS-FIR—HEMLOCK

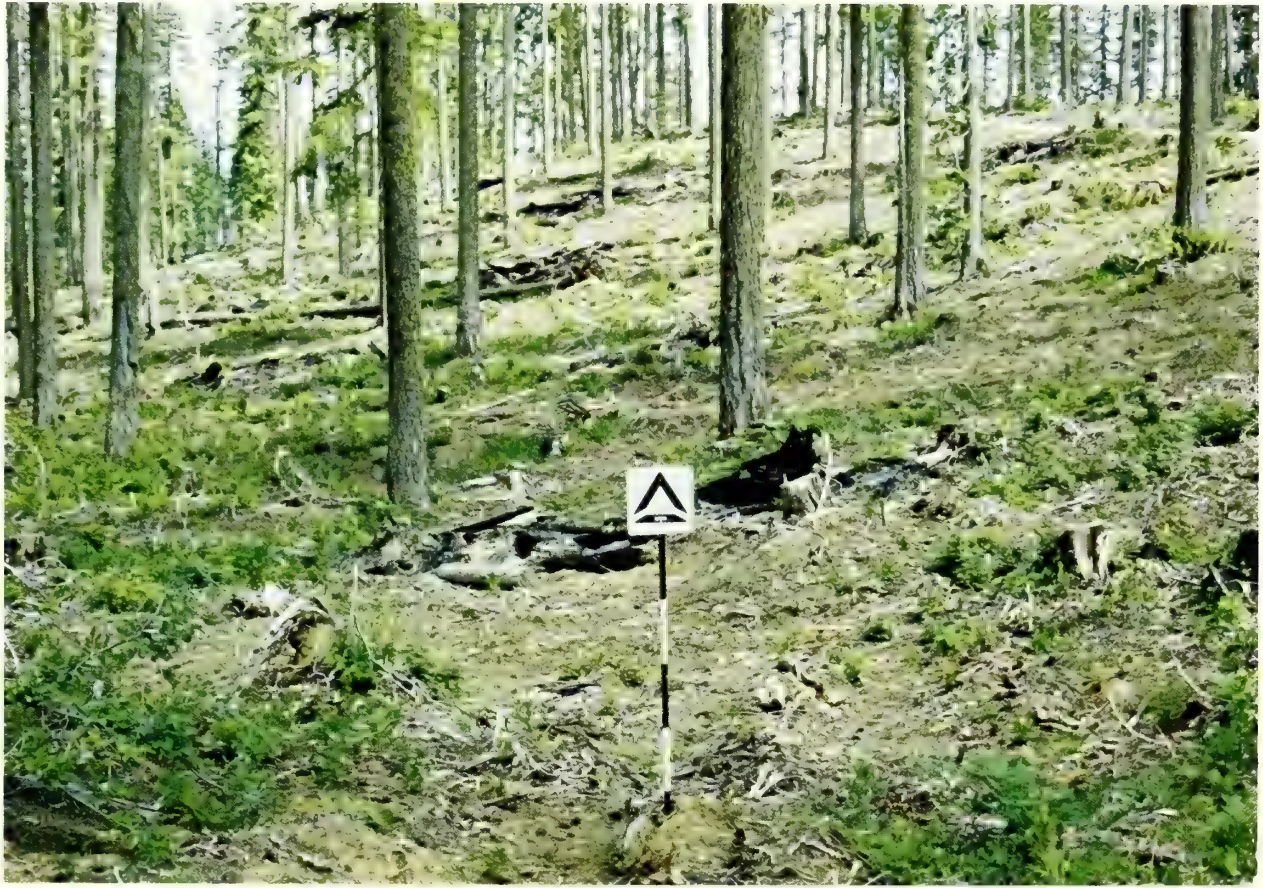
SIZE CLASS 4

PARTIAL CUT

A SERIES OF 9 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-DF-4-PC

DATA SHEET

Residue descriptive code 1-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.1	61
1.1-3.0	2.3	143
3.1-9.0	2.3	174
9.1-20.0	1.0	65
20.1+	0	0
Total	6.7	443

OTHER MEASUREMENTS

Average residue depth (feet) 0.1

Ground area covered by residue 1/4-inch diameter and larger (percent) 40

Average duff and litter depth (inches) 0.7

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 79

(percent)

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 21

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	51
Net volume cruised (M fbm/acre)	39
Average stems/acre cut	52
Average d.b.h. of stems cut (inches)	27
Stand age (years)	300
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	12

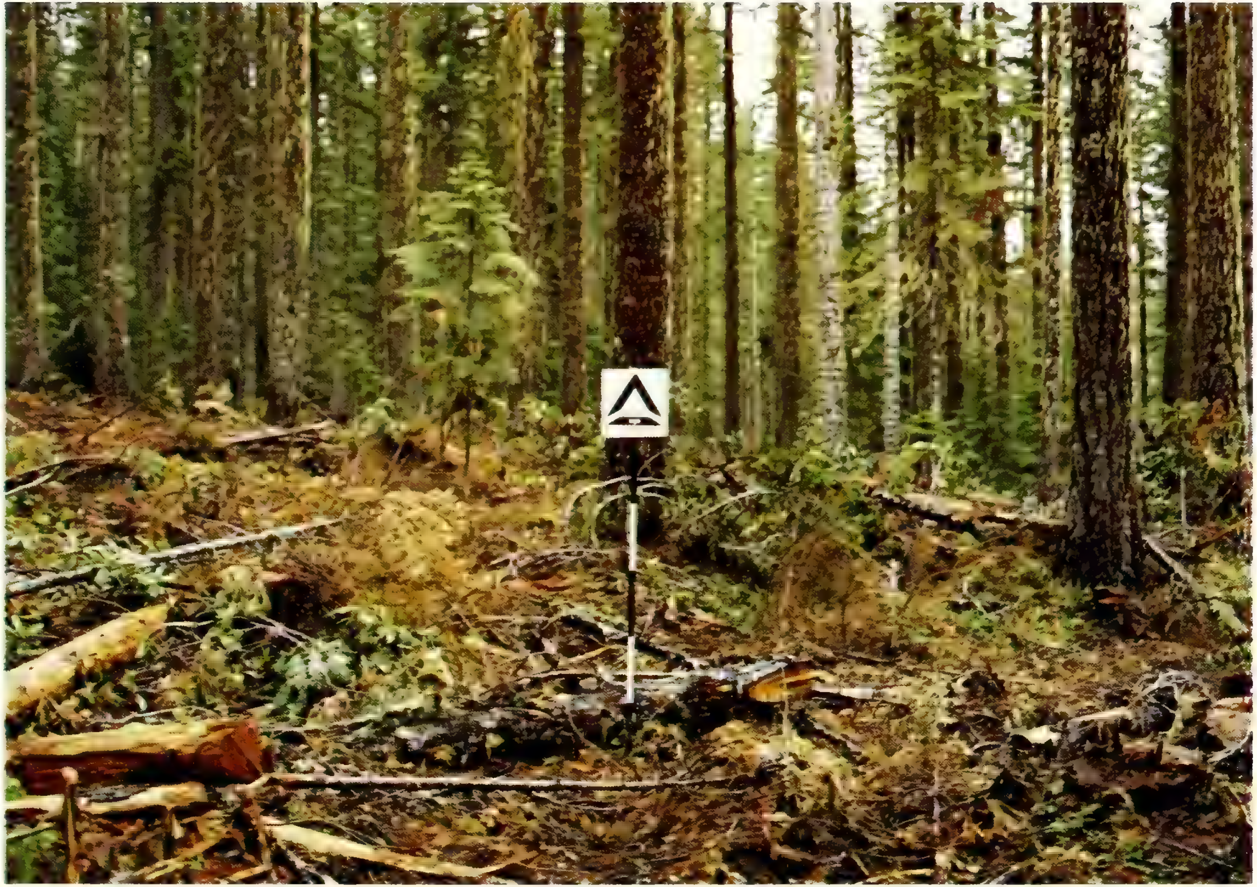
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



2-DF-4-PC

DATA SHEET Residue descriptive code 2-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.9	124
1.1-3.0	3.6	289
3.1-9.0	6.3	483
9.1-20.0	8.1	547
20.1+	0	0
Total	19.9	1,443

OTHER MEASUREMENTS

Average residue depth	(feet)	0.5
Ground area covered by residue 1/4-inch diameter and larger	(percent)	76
Average duff and litter depth	(inches)	1.4
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	54
western hemlock	(percent)	21
other	(percent)	21
Rotted residue 3.1-inch diameter and larger	(percent)	4

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	26
Net volume cruised (M fbm/acre)	21
Average stems/acre cut	52
Average d.b.h. of stems cut (inches)	22
Stand age (years)	170+
Cutting prescription	Tree selection
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	<6

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______

Stems remaining/acre ______

Basal area/acre before ______

Basal area/acre after ______

Average d.b.h. before (inches) ______

Average d.b.h. after (inches) ______

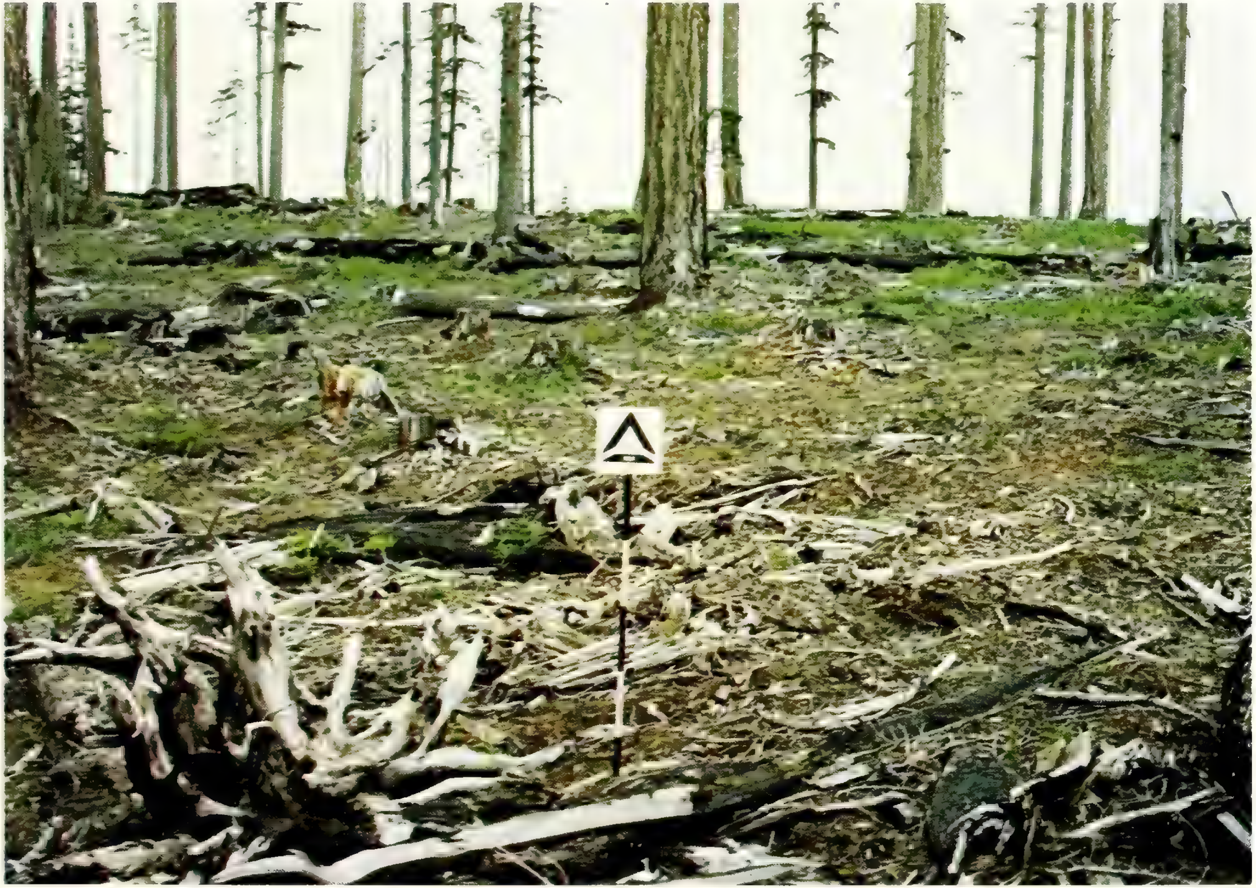
Thinning method ______

Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS



3-DF-4-PC

DATA SHEET

Residue descriptive code 3-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.6	108
1.1-3.0	2.7	214
3.1-9.0	5.7	389
9.1-20.0	7.9	534
20.1+	3.0	200
Total	20.9	1,445

OTHER MEASUREMENTS

Average residue depth		(feet)	0.1
Ground area covered by residue 1/4-inch diameter and larger		(percent)	36
Average duff and litter depth		(inches)	0.6
Sound residue 3.1-inch diameter and larger	Douglas-fir	(percent)	84
	western hemlock	(percent)	11
	other	(percent)	5
Rotted residue 3.1-inch diameter and larger		(percent)	0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	43
Net volume cruised (M fbm/acre)	20
Average stems/acre cut	20
Average d.b.h. of stems cut (inches)	30
Stand age (years)	300
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	24

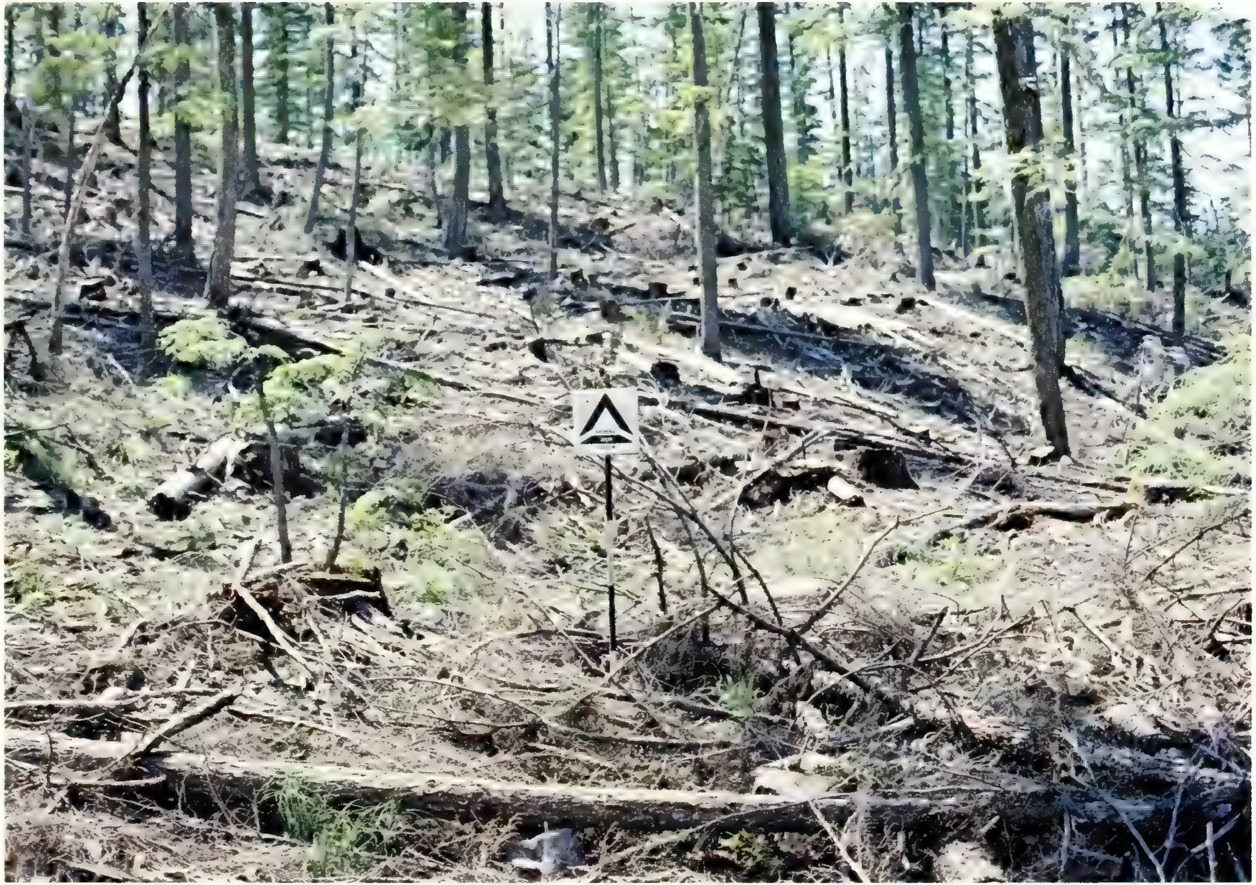
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



4-DF-4-PC

DATA SHEET

Residue descriptive code 4-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.5	232
1.1-3.0	5.8	461
3.1-9.0	16.0	1,243
9.1-20.0	2.6	258
20.1+	0	0
Total	27.9	2,194

OTHER MEASUREMENTS

Average residue depth		(feet)	0.8
Ground area covered by residue 1/4-inch diameter and larger		(percent)	95
Average duff and litter depth		(inches)	4.8
Sound residue 3.1-inch diameter and larger	western hemlock	(percent)	63
	white fir	(percent)	3
	other	(percent)	1
Rotted residue 3.1-inch diameter and larger		(percent)	33

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	43
Net volume cruised (M fbm/acre)	33
Average stems/acre cut	94
Average d.b.h. of stems cut (inches)	18
Stand age (years)	250
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	9

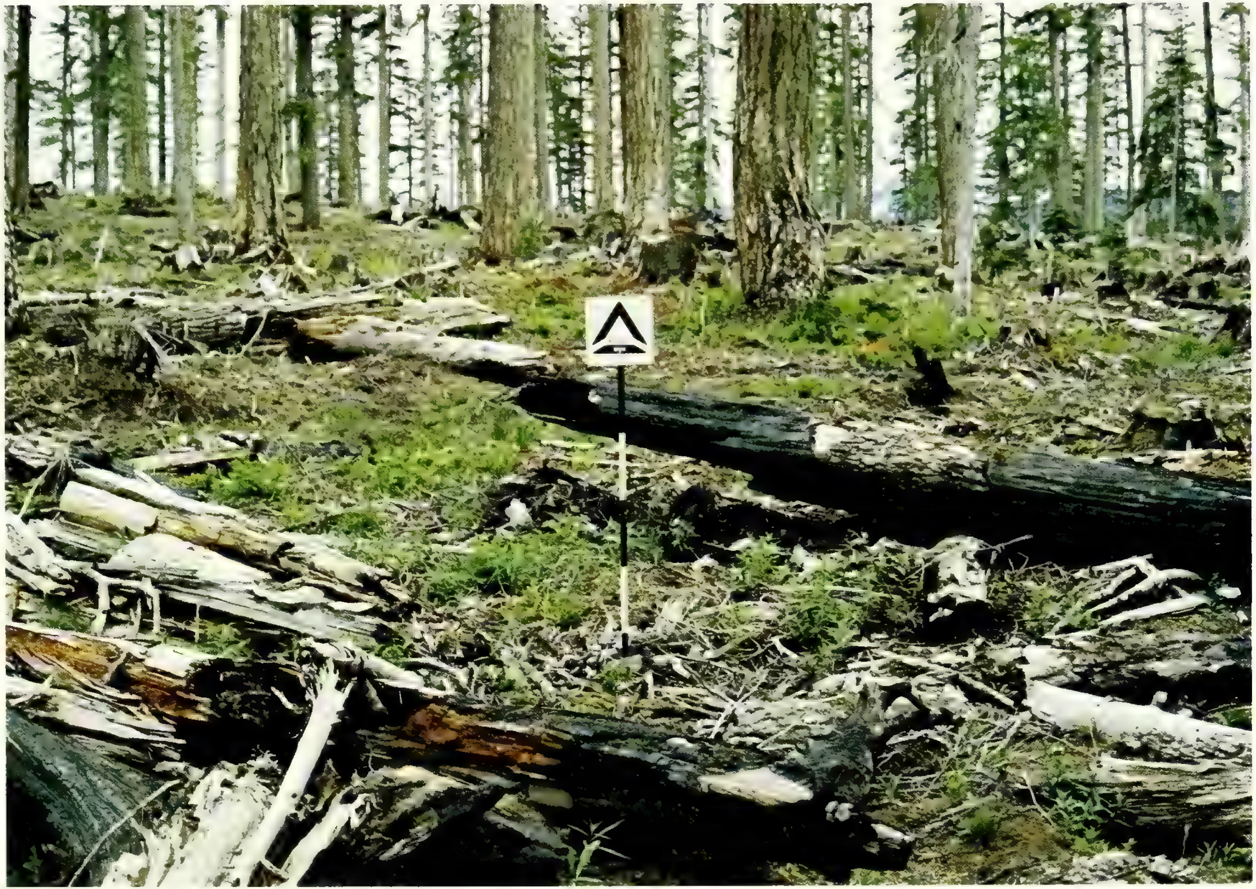
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	HH

REMARKS



5-DF-4-PC

DATA SHEET

Residue descriptive code 5-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.4	91
1.1-3.0	3.1	247
3.1-9.0	6.8	488
9.1-20.0	13.2	898
20.1+	10.5	698
Total	35.0	2,422

OTHER MEASUREMENTS

Average residue depth	(feet)	0.2
Ground area covered by residue 1/4-inch diameter and larger	(percent)	40
Average duff and litter depth	(inches)	1.1
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	84
western hemlock	(percent)	10
other	(percent)	1
Rotted residue 3.1-inch diameter and larger	(percent)	5

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	53
Net volume cruised (M fbm/acre)	19
Average stems/acre cut	20
Average d.b.h. of stems cut (inches)	30
Stand age (years)	300
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	16

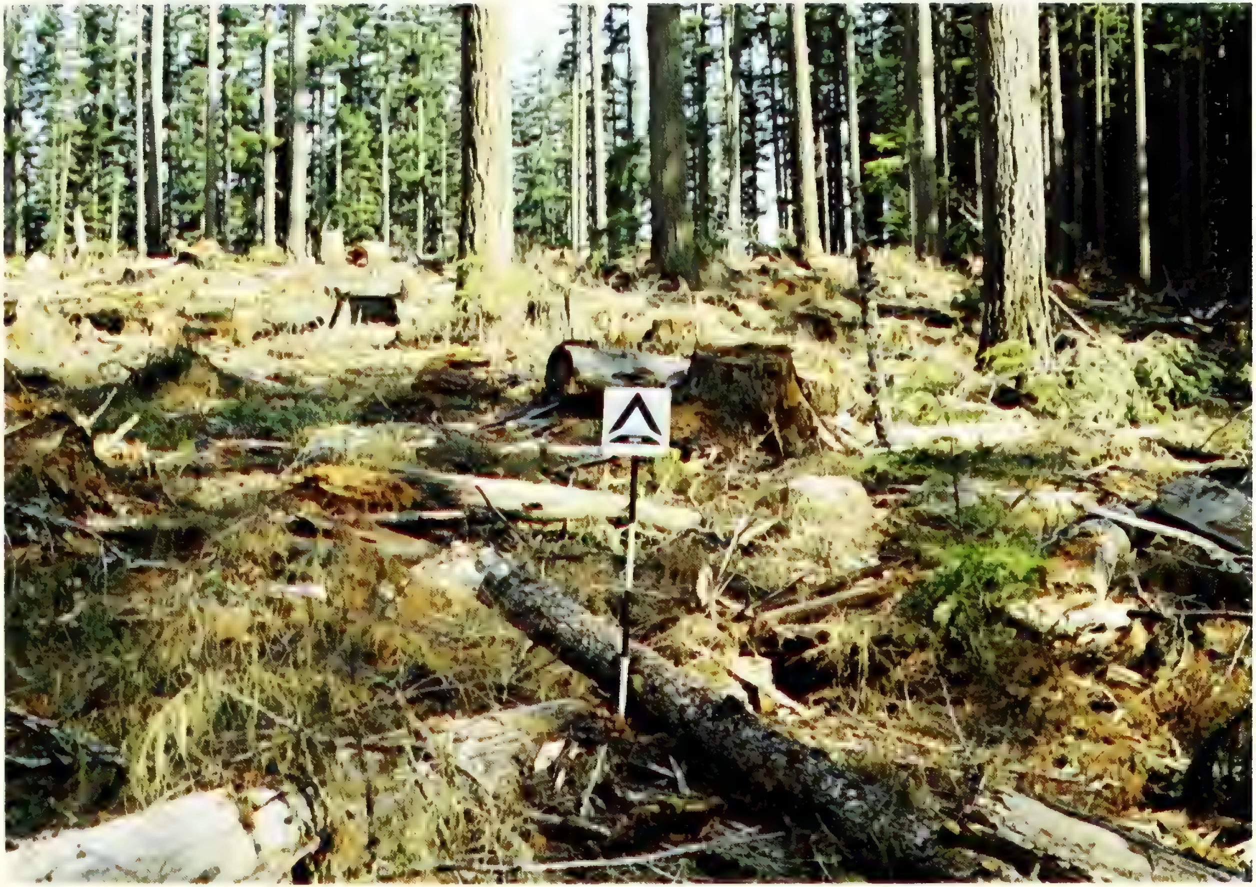
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	LM

REMARKS



6-DF-4-PC

DATA SHEET

Residue descriptive code 6-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.6	148
1.1-3.0	6.2	382
3.1-9.0	12.6	893
9.1-20.0	27.6	2,009
20.1+	4.3	282
Total	53.3	3,714

OTHER MEASUREMENTS

Average residue depth	(feet)	0.7
Ground area covered by residue 1/4-inch diameter and larger	(percent)	89
Average duff and litter depth	(inches)	3.3
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	79
western hemlock	(percent)	3
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	18

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	116
Net volume cruised (M fbm/acre)	89
Average stems/acre cut	55
Average d.b.h. of stems cut (inches)	32
Stand age (years)	250+
Cutting prescription	Shelterwood
Yarding method	High-lead
Slash treatment	None
Period since cut or treatment (months)	1

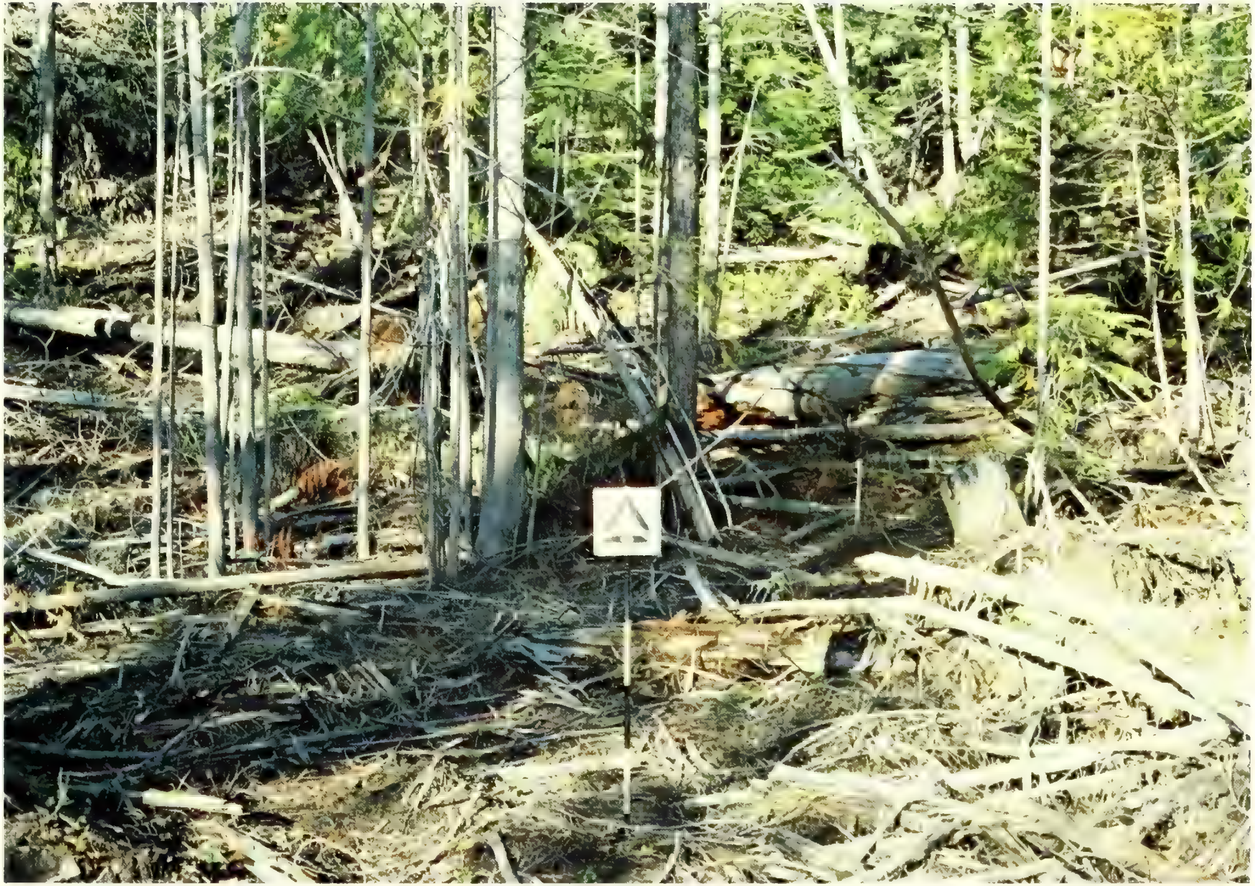
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	HH

REMARKS



7-DF-4-PC

DATA SHEET

Residue descriptive code 7-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.6	240
1.1-3.0	9.5	759
3.1-9.0	14.6	1,128
9.1-20.0	2.5	192
20.1+	31.6	2,463
Total	61.8	4,782

OTHER MEASUREMENTS

Average residue depth		(feet)	0.7
Ground area covered by residue 1/4-inch diameter and larger		(percent)	96
Average duff and litter depth		(inches)	5.2
Sound residue 3.1-inch diameter and larger	Douglas-fir	(percent)	56
	western redcedar	(percent)	35
	other	(percent)	3
Rotted residue 3.1-inch diameter and larger		(percent)	6

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	44
Net volume cruised (M fbm/acre)	28
Average stems/acre cut	15
Average d.b.h. of stems cut (inches)	38
Stand age (years)	250
Cutting prescription	Overstory removal
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	8

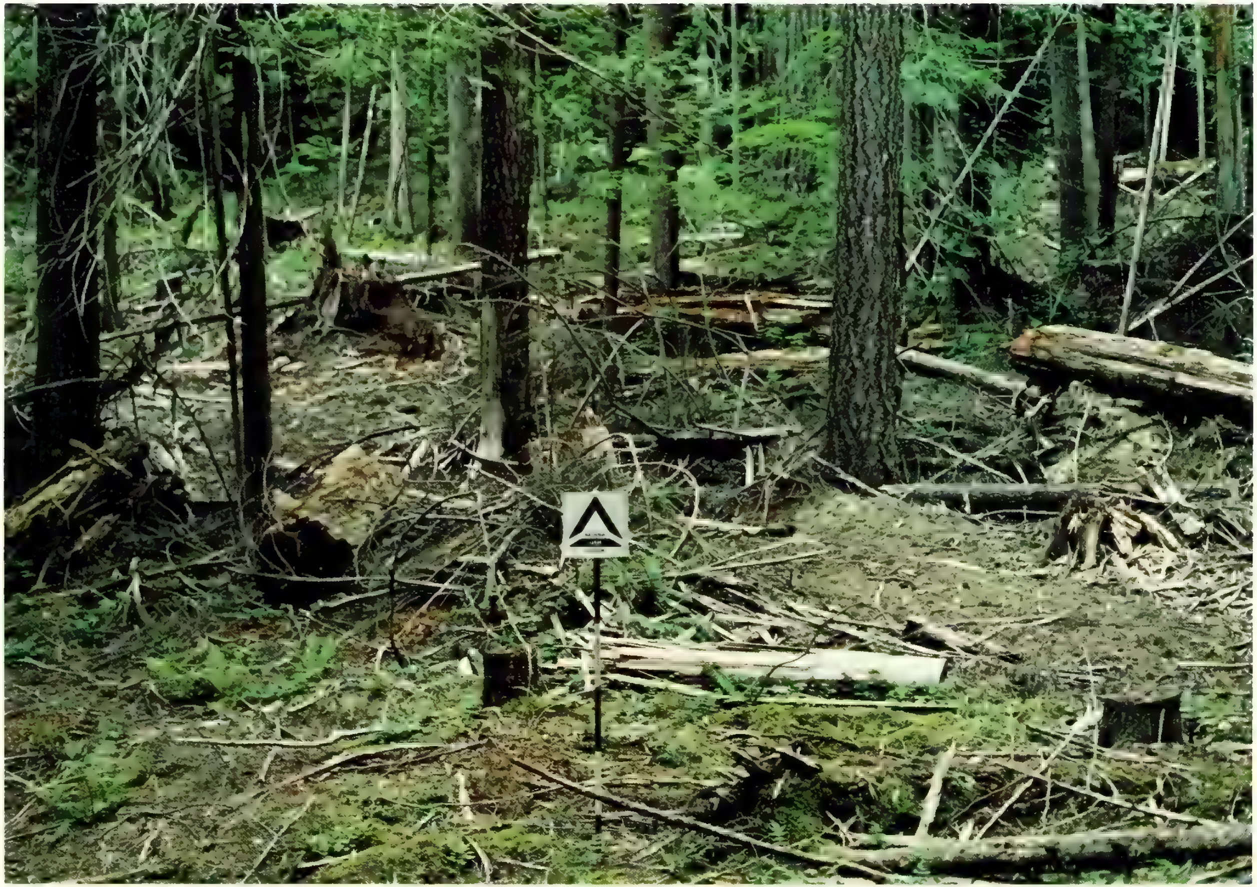
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	HE

REMARKS



8-DF-4-PC

DATA SHEET

Residue descriptive code 8-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.6	237
1.1-3.0	8.5	680
3.1-9.0	9.9	875
9.1-20.0	26.5	2,588
20.1+	40.2	3,992
Total	88.7	8,372

OTHER MEASUREMENTS

Average residue depth		(feet)	1.9
Ground area covered by residue 1/4-inch diameter and larger		(percent)	95
Average duff and litter depth		(inches)	8.6
Sound residue 3.1-inch diameter and larger	western redcedar	(percent)	18
	Douglas-fir	(percent)	12
	other	(percent)	2
Rotted residue 3.1-inch diameter and larger		(percent)	68

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	16
Net volume cruised (M fbm/acre)	11
Average stems/acre cut	26
Average d.b.h. of stems cut (inches)	20
Stand age (years)	450
Cutting prescription	Tree selection
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	8

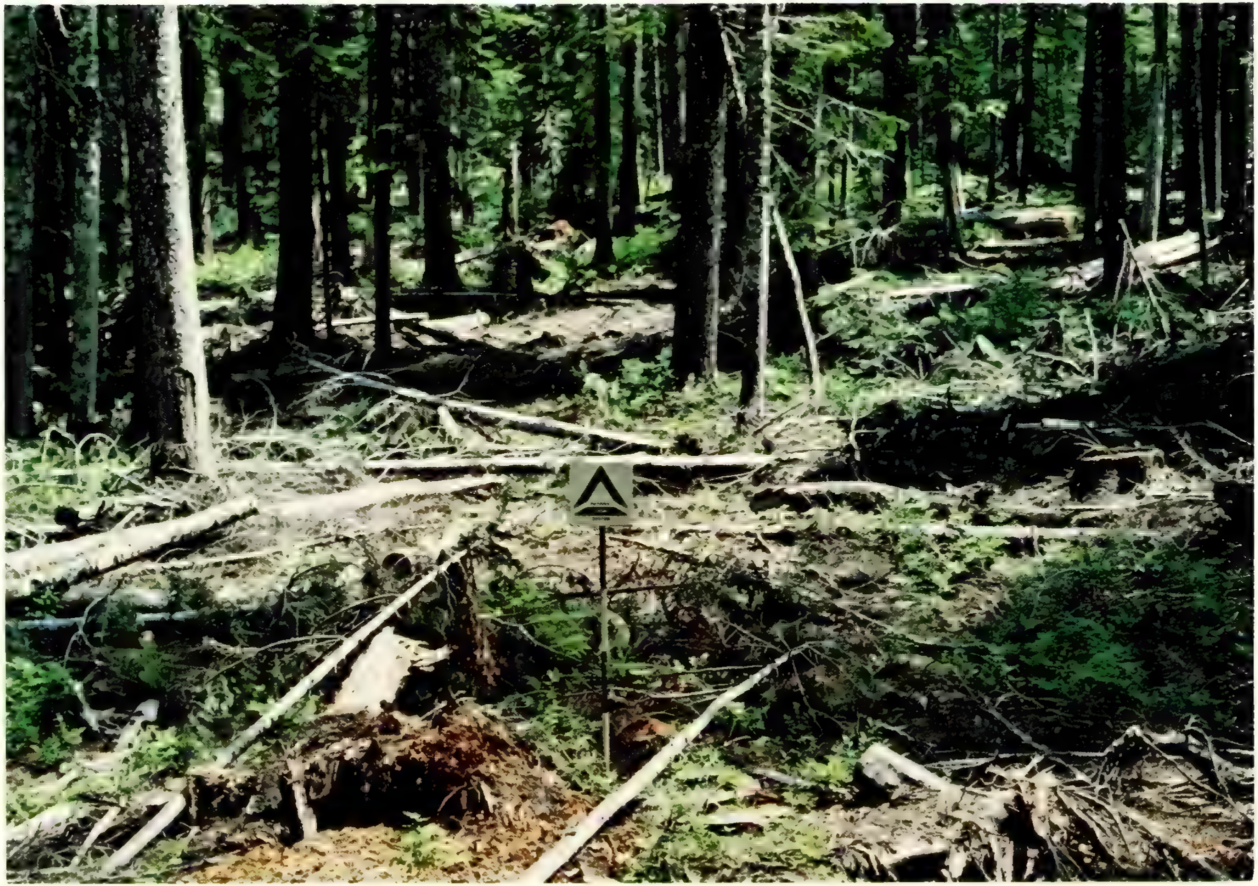
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



9-DF-4-PC

DATA SHEET

Residue descriptive code 9-DF-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.3	156
1.1-3.0	4.9	396
3.1-9.0	11.9	879
9.1-20.0	25.6	1,927
20.1+	63.6	4,355
Total	108.3	7,713

OTHER MEASUREMENTS

Average residue depth (feet) 0.6
Ground area covered by residue 1/4-inch diameter and larger (percent) 75
Average duff and litter depth (inches) 3.3
Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 56
western hemlock (percent) 33
other (percent) 2
Rotted residue 3.1-inch diameter and larger (percent) 9

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 15
Net volume cruised (M fbm/acre) 11
Average stems/acre cut 32
Average d.b.h. of stems cut (inches) 20
Stand age (years) 100+
Cutting prescription Tree selection
Yarding method Rubber-tired skidder
Slash treatment None
Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS

DOUGLAS-FIR–HEMLOCK

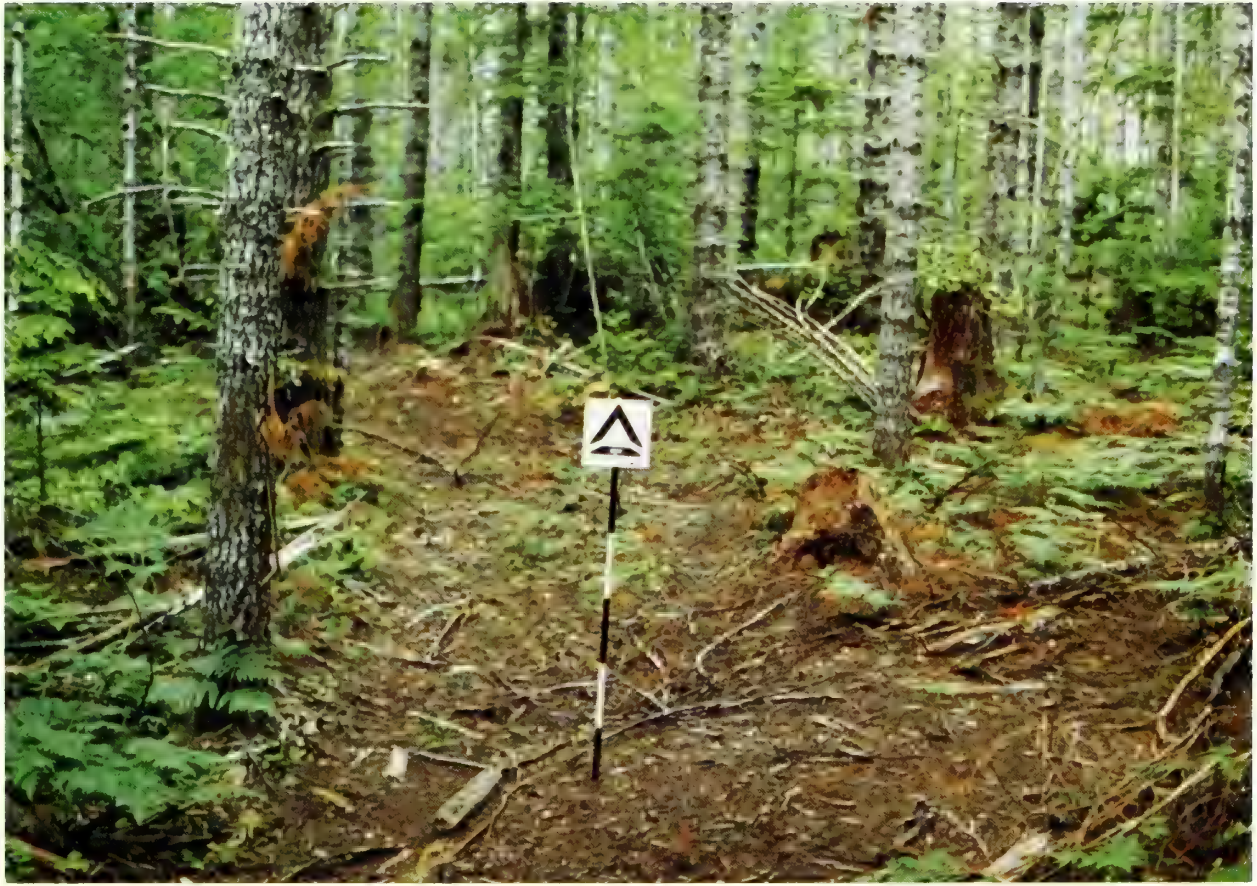
SIZE CLASS 3

PARTIAL CUT

A SERIES OF 6 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-DF-3-PC

DATA SHEET

Residue descriptive code 1-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.3	85
1.1-3.0	2.8	224
3.1-9.0	4.8	356
9.1-20.0	0	0
20.1+	0	0
Total	8.9	665

OTHER MEASUREMENTS

Average residue depth	(feet)	0.4
Ground area covered by residue 1/4-inch diameter and larger	(percent)	76
Average duff and litter depth	(inches)	1.3
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	71
western redcedar	(percent)	13
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	16

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	8.2
Net volume cruised (M fbm/acre)	7.9
Average stems/acre cut	41
Average d.b.h. of stems cut (inches)	12
Stand age (years)	60
Cutting prescription	Tree selection
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	1

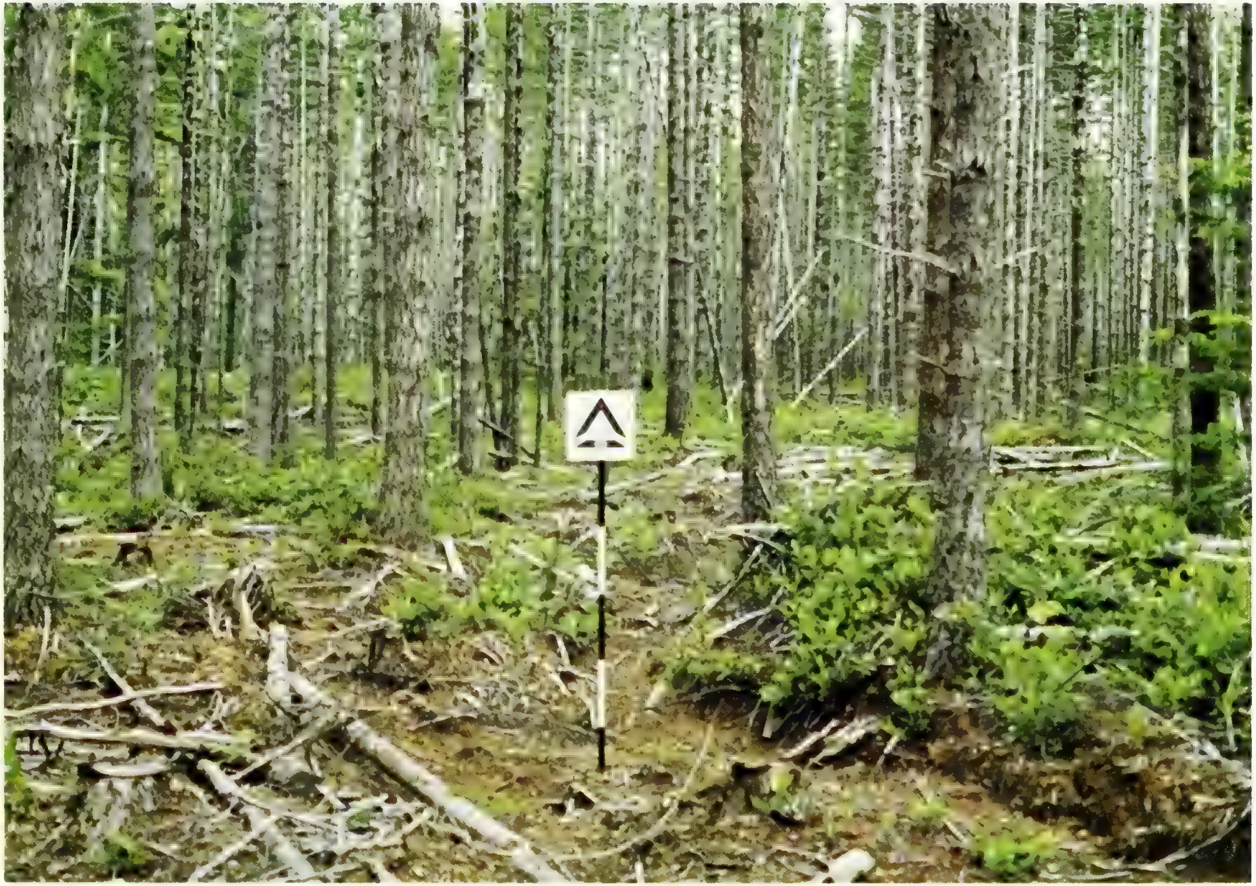
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LM

REMARKS



2-DF-3-PC

DATA SHEET

Residue descriptive code 2-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.0	112
1.1-3.0	2.1	129
3.1-9.0	10.8	733
9.1-20.0	0	0
20.1+	0	0
Total	14.9	974

OTHER MEASUREMENTS

Average residue depth (feet) 0.2
Ground area covered by residue 1/4-inch diameter and larger (percent) 68
Average duff and litter depth (inches) 1.3
Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 96
______ (percent) ____
______ (percent) ____
Rotted residue 3.1-inch diameter and larger (percent) 4

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 3.0
Net volume cruised (M fbm/acre) 2.8
Average stems/acre cut 35
Average d.b.h. of stems cut (inches) 12
Stand age (years) 50
Cutting prescription Tree selection
Yarding method Rubber-tired skidder
Slash treatment None
Period since cut or treatment (months) 8

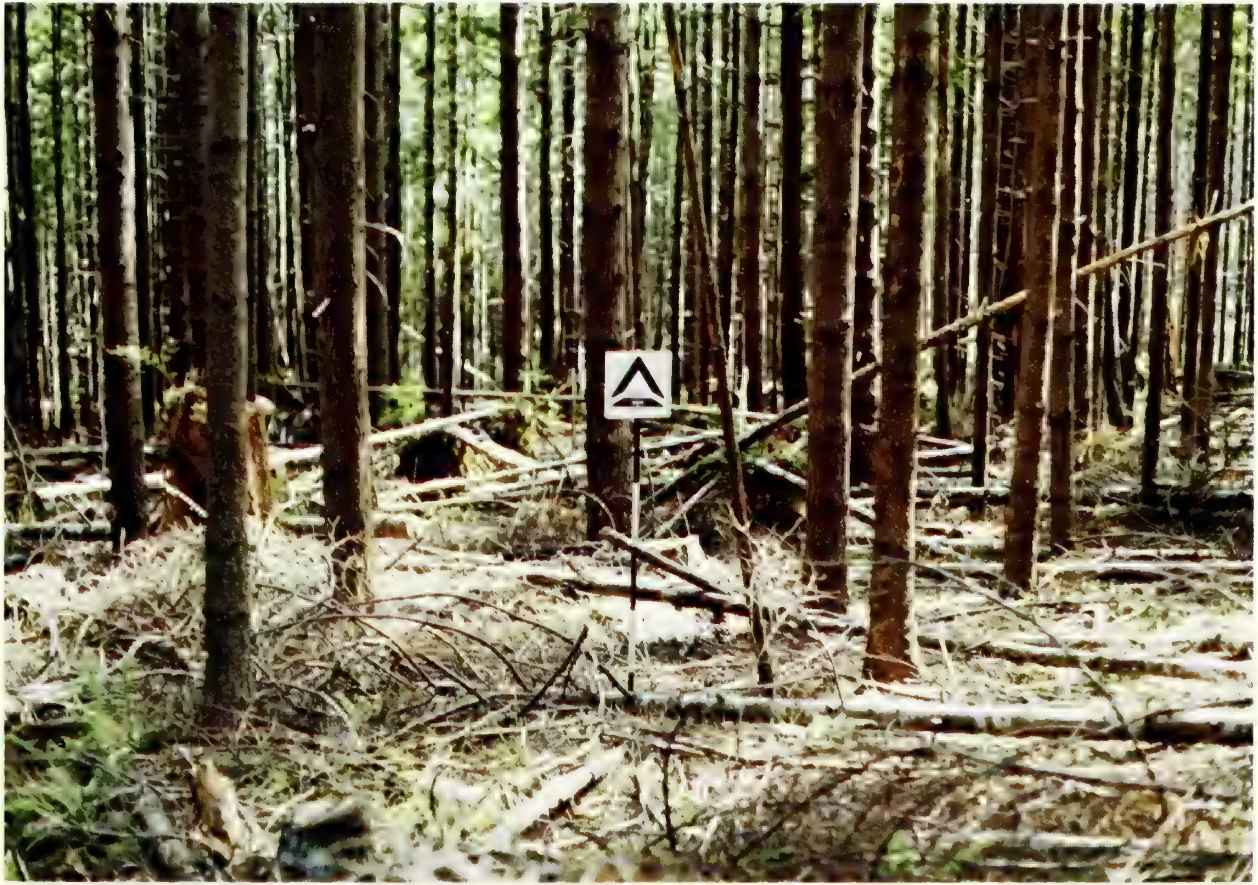
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____
Stems remaining/acre ____
Basal area/acre before ____
Basal area/acre after ____
Average d.b.h. before (inches) ____
Average d.b.h. after (inches) ____
Thinning method ____
Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MM

REMARKS



3-DF-3-PC

DATA SHEET

Residue descriptive code 3-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.7	116
1.1-3.0	3.6	289
3.1-9.0	14.6	1,057
9.1-20.0	6.8	728
20.1+	0	0
Total	26.7	2,190

OTHER MEASUREMENTS

Average residue depth	(feet)	0.5
Ground area covered by residue 1/4-inch diameter and larger	(percent)	91
Average duff and litter depth	(inches)	2.0
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	47
western redcedar	(percent)	2
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	51

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	4.7
Net volume cruised (M fbm/acre)	4.5
Average stems/acre cut	44
Average d.b.h. of stems cut (inches)	13
Stand age (years)	45
Cutting prescription	Tree selection
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	8

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____

Stems remaining/acre ____

Basal area/acre before ____

Basal area/acre after ____

Average d.b.h. before (inches) ____

Average d.b.h. after (inches) ____

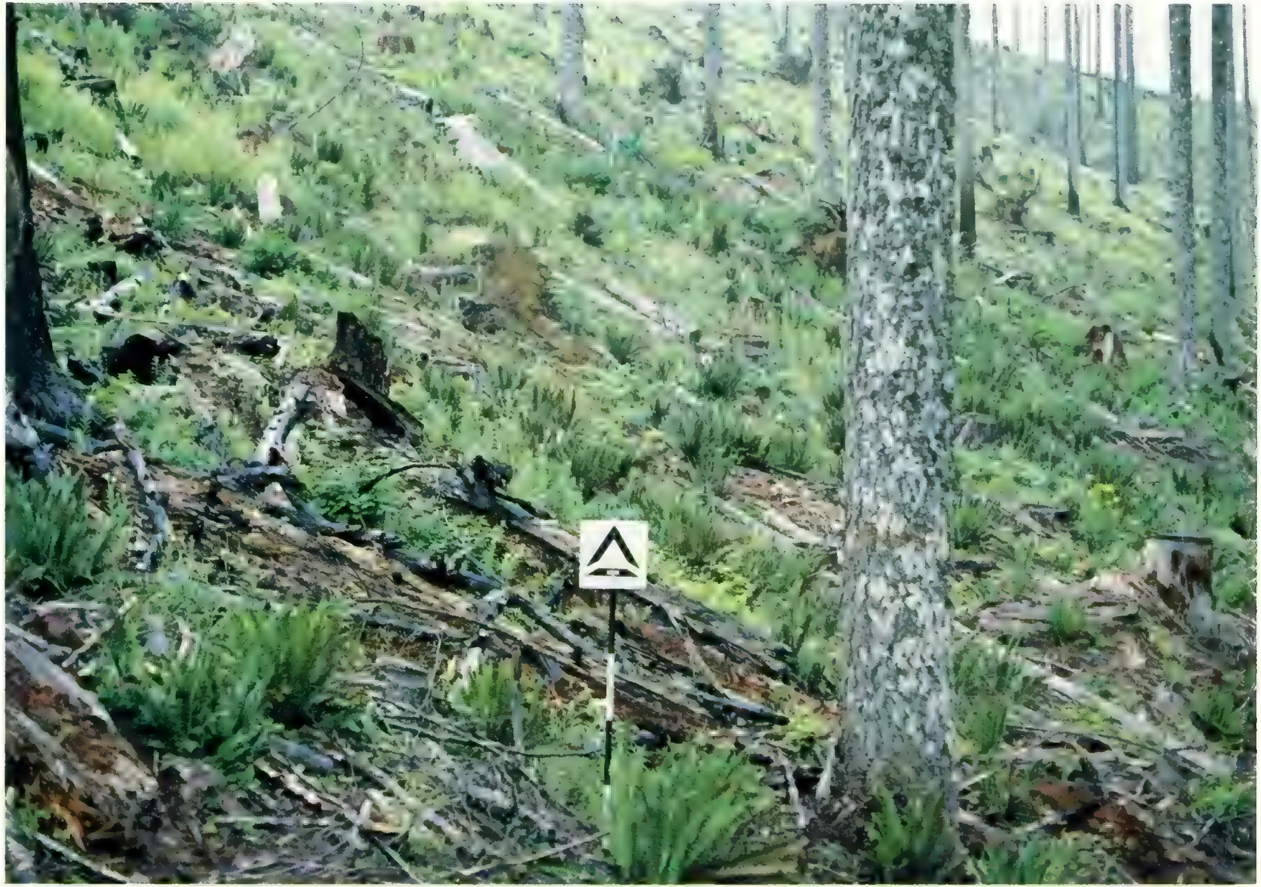
Thinning method ____

Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



4-DF-3-PC

DATA SHEET

Residue descriptive code 4-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.9	108
1.1-3.0	8.0	495
3.1-9.0	21.1	1,546
9.1-20.0	31.9	2,860
20.1+	2.6	281
Total	65.5	5,290

OTHER MEASUREMENTS

Average residue depth (feet) 0.5
Ground area covered by residue 1/4-inch diameter and larger (percent) 83
Average duff and litter depth (inches) 8.2
Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 45
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 55

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 66.1
Net volume cruised (M fbm/acre) 59.6
Average stems/acre cut 105
Average d.b.h. of stems cut (inches) 22
Stand age (years) 90
Cutting prescription Shelterwood
Yarding method High-lead
Slash treatment Fall broadcast burn
Period since cut or treatment (months) 22

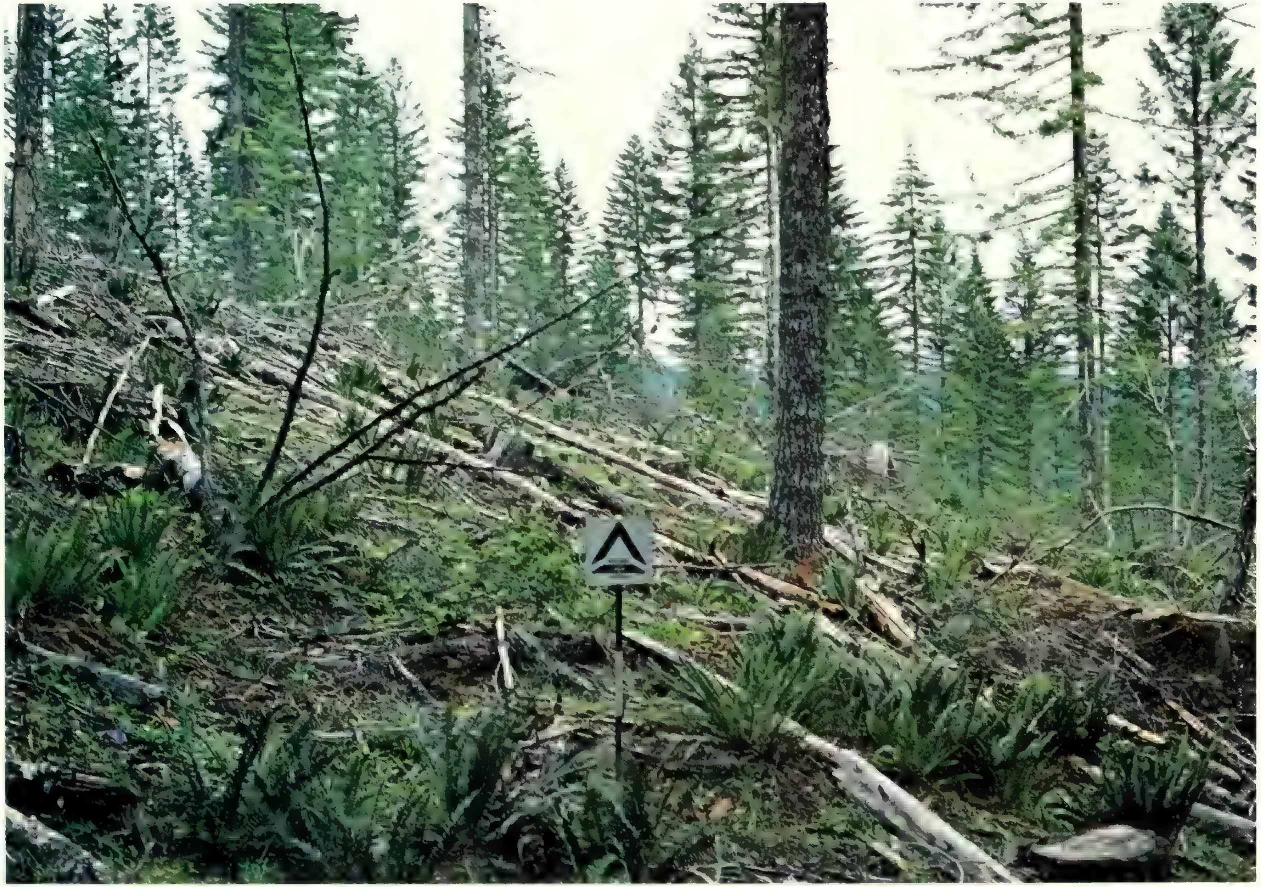
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



5-DF-3-PC

DATA SHEET

Residue descriptive code 5-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	4.5	260
1.1-3.0	18.6	1,146
3.1-9.0	16.3	1,201
9.1-20.0	10.6	898
20.1+	26.6	2,457
Total	76.6	5,962

OTHER MEASUREMENTS

Average residue depth	(feet)	0.9
Ground area covered by residue 1/4-inch diameter and larger	(percent)	97
Average duff and litter depth	(inches)	5.4
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	41
cherry	(percent)	1
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	58

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	27.2
Net volume cruised (M fbm/acre)	25.6
Average stems/acre cut	64
Average d.b.h. of stems cut (inches)	24
Stand age (years)	80
Cutting prescription	Shelterwood
Yarding method	High-lead
Slash treatment	None
Period since cut or treatment (months)	10

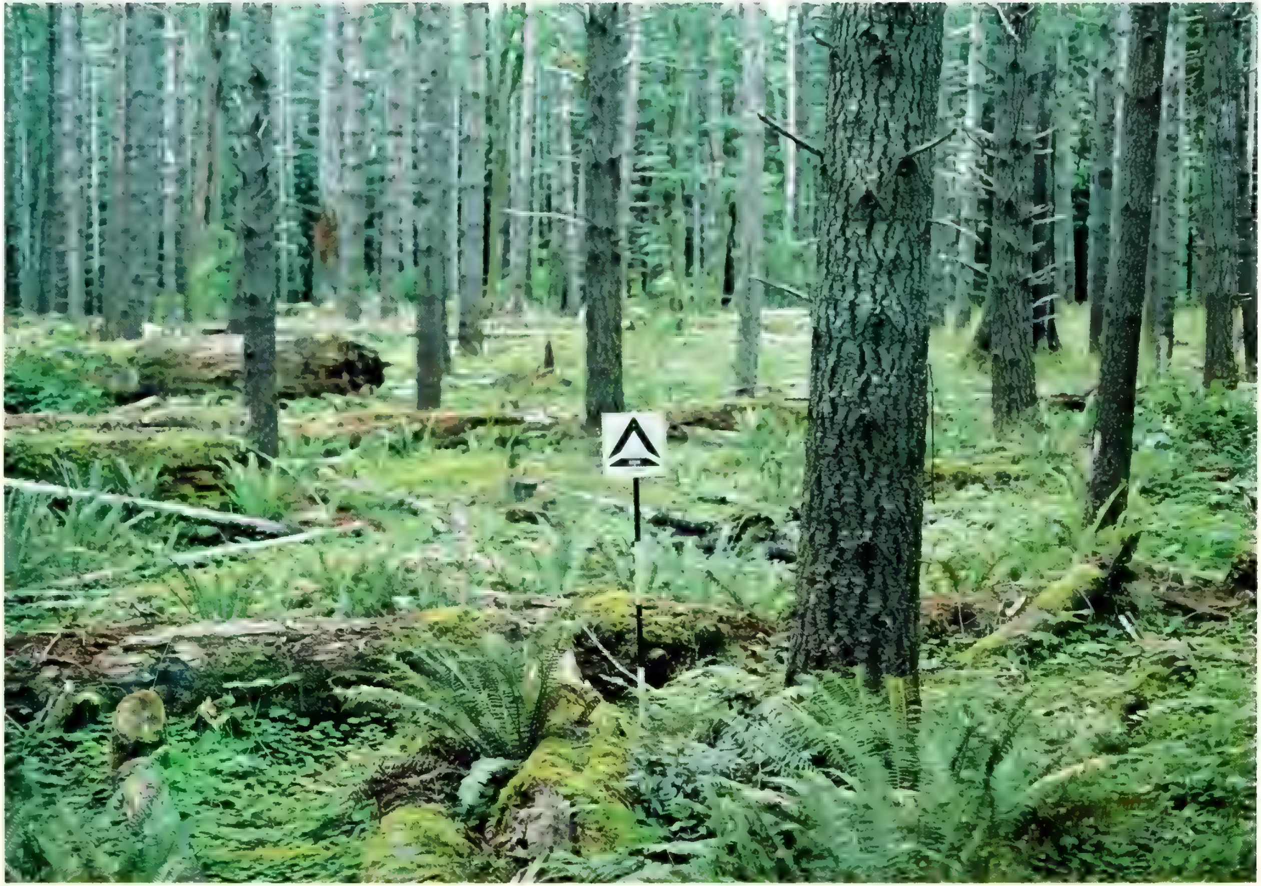
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



6-DF-3-PC

DATA SHEET

Residue descriptive code 6-DF-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.8	122
1.1-3.0	2.6	205
3.1-9.0	14.4	1,106
9.1-20.0	4.5	354
20.1+	64.4	4,882
Total	87.7	6,669

OTHER MEASUREMENTS

Average residue depth (feet) 0.3

Ground area covered by residue 1/4-inch diameter and larger (percent) 71

Average duff and litter depth (inches) 1.8

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 61

white fir (percent) 6

other (percent) 2

Rotted residue 3.1-inch diameter and larger (percent) 31

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 6.3

Net volume cruised (M fbm/acre) 5.7

Average stems/acre cut 46

Average d.b.h. of stems cut (inches) 11

Stand age (years) 50

Cutting prescription Tree selection

Yarding method Tractor

Slash treatment Hand piled & burned

Period since cut or treatment (months) 12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____

Stems remaining/acre ____

Basal area/acre before ____

Basal area/acre after ____

Average d.b.h. before (inches) ____

Average d.b.h. after (inches) ____

Thinning method ____

Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LM

REMARKS

Material 9.1+ inches in diameter was a result of logging old-growth stand in early 1900's.

DOUGLAS-FIR—HEMLOCK

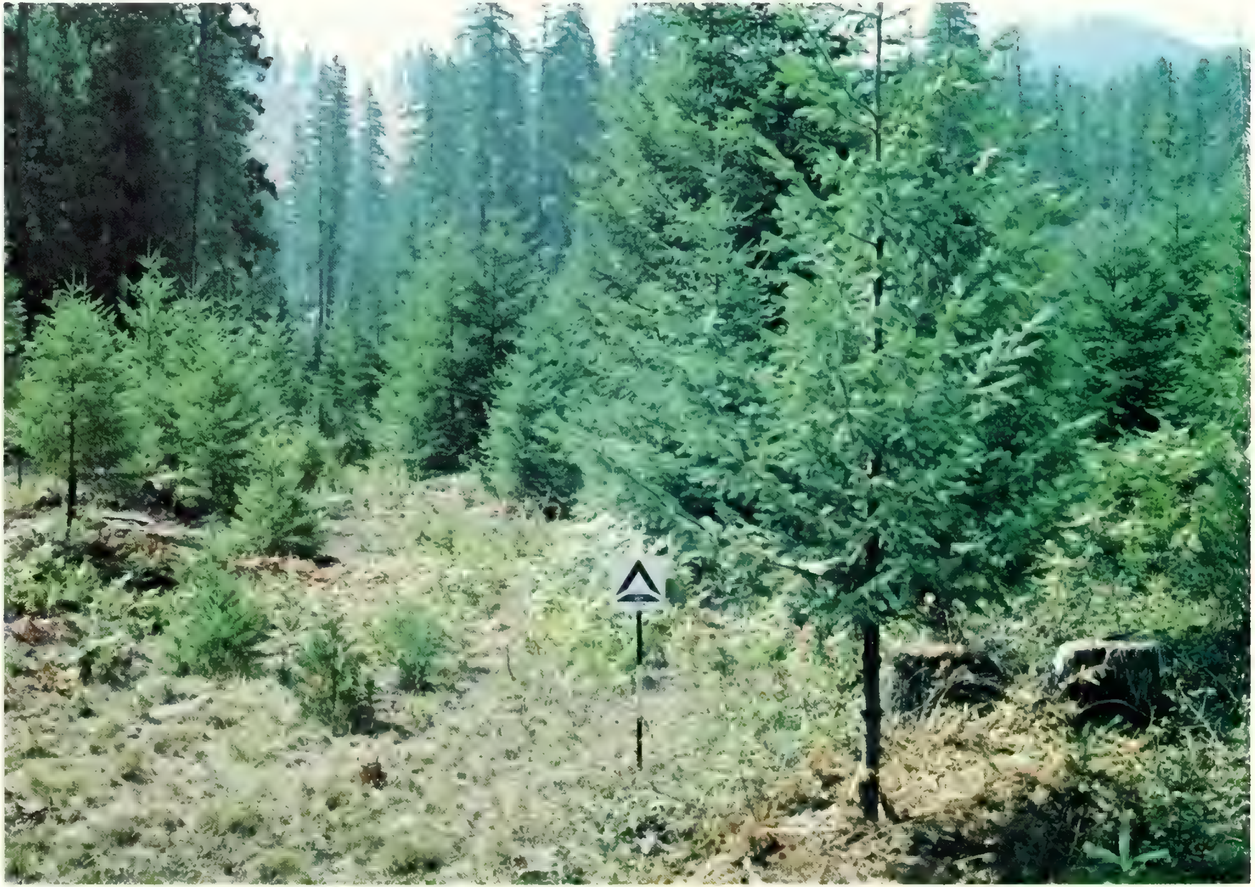
SIZE CLASS 1

PRECOMMERCIAL THINNING

A SERIES OF 4 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-DF-1-TH

DATA SHEET

Residue descriptive code 1-DF-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	0.4	0	27	0
1.1-3.0	0.4	0	28	0
3.1-9.0	0	[1]1.4	0	[1]117
9.1-20.0	0	[1]6.0	0	[1]606
20.1+	0	[1]10.8	0	[1]724
Total	0.8	[1]18.2	55	[1]1,447

OTHER MEASUREMENTS

Average residue depth (feet) 0.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 33

Average duff and litter depth (inches) 1.3

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 56

western redcedar (percent) 14

(percent) ___

Rotted residue 3.1-inch diameter and larger (percent) 30

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) ___

Net volume cruised (M fbm/acre) ___

Average stems/acre cut ___

Average d.b.h. of stems cut (inches) ___

Stand age (years) ___

Cutting prescription ___

Yarding method ___

Slash treatment ___

Period since cut or treatment (months ___

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 1,547

Stems remaining/acre 700

Basal area/acre before 196

Basal area/acre after 61

Average d.b.h. before (inches) 4

Average d.b.h. after (inches) 4

Thinning method Chainsaw

Slash treatment Chipped

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS

Residue loadings footnoted were present prior to thinning.

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[1] See remarks.

2-DF-1-TH

DATA SHEET

Residue descriptive code 2-DF-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	0.7	0	41	0
1.1-3.0	0.9	0	57	0
3.1-9.0	0	1/ 2.2	0	1/ 239
9.1-20.0	0	1/ 16.3	0	1/ 1,744
20.1+	0	1/ 75.0	0	1/ 8,015
Total	1.6	1/ 93.5	98	1/ 9,998

OTHER MEASUREMENTS

Average residue depth (feet) 0.4

Ground area covered by residue 1/4-inch diameter and larger (percent) 61

Average duff and litter depth (inches) 1.0

Sound residue 3.1-inch diameter and larger ________ (percent) ____

________ (percent) ____

________ (percent) ____

Rotted residue 3.1-inch diameter and larger (percent) 100

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) ____

Net volume cruised (M fbm/acre) ____

Average stems/acre cut ____

Average d.b.h. of stems cut (inches) ____

Stand age (years) ____

Cutting prescription ________

Yarding method ________

Slash treatment ________

Period since cut or treatment (months ____

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 1,057

Stems remaining/acre 241

Basal area/acre before 113

Basal area/acre after 47

Average d.b.h. before (inches) 4

Average d.b.h. after (inches) 6

Thinning method Chainsaw

Slash treatment Hand piled & burned

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LH

REMARKS

Residue loadings footnoted were present prior to thinning.

1/ See remarks.

3-DF-1-TH

DATA SHEET

Residue descriptive code 3-DF-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	2.1	0	122	0
1.1-3.0	2.9	0	181	0
3.1-9.0	2.7	[1] 2.9	171	[1] 267
9.1-20.0	0	[1] 10.1	0	[1] 866
20.1+	0	0	0	0
Total	7.7	[1] 13.0	474	[1] 1,133

OTHER MEASUREMENTS

Average residue depth (feet) 1.0

Ground area covered by residue 1/4-inch diameter and larger (percent) 69

Average duff and litter depth (inches) 0.9

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 40

chinkapin (percent) 2

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 58

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)

Net volume cruised (M fbm/acre)

Average stems/acre cut

Average d.b.h. of stems cut (inches)

Stand age (years)

Cutting prescription

Yarding method

Slash treatment

Period since cut or treatment (months

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 159

Stems remaining/acre 219

Basal area/acre before 52

Basal area/acre after 43

Average d.b.h. before (inches) 5

Average d.b.h. after (inches) 6

Thinning method Chainsaw

Slash treatment None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Residue loadings footnoted were present prior to thinning

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[1] See remarks.

4-DF-1-TH

DATA SHEET

Residue descriptive code 4-DF-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	4.1	0	272	0
1.1-3.0	5.3	0	422	0
3.1-9.0	1.6	[1]14.9	108	[1]1,072
9.1-20.0	0	[1]15.5	0	[1]1,054
20.1+	0	[1]81.5	0	[1]5,620
Total	11.0	[1]111.9	802	[1]7,746

OTHER MEASUREMENTS

Average residue depth (feet) 2.3

Ground area covered by residue 1/4-inch diameter and larger (percent) 93

Average duff and litter depth (inches) 1.3

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 90

western redcedar (percent) 7

(percent) ___

Rotted residue 3.1-inch diameter and larger (percent) 3

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) ___

Net volume cruised (M fbm/acre) ___

Average stems/acre cut ___

Average d.b.h. of stems cut (inches) ___

Stand age (years) ___

Cutting prescription ___

Yarding method ___

Slash treatment ___

Period since cut or treatment (months ___

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 1,058

Stems remaining/acre 317

Basal area/acre before 120

Basal area/acre after 43

Average d.b.h. before (inches) 4

Average d.b.h. after (inches) 5

Thinning method Chainsaw

Slash treatment None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HE

REMARKS

Residue loadings footnoted were present prior to thinning.

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[1] See remarks.

DOUGLAS-FIR–HARDWOOD

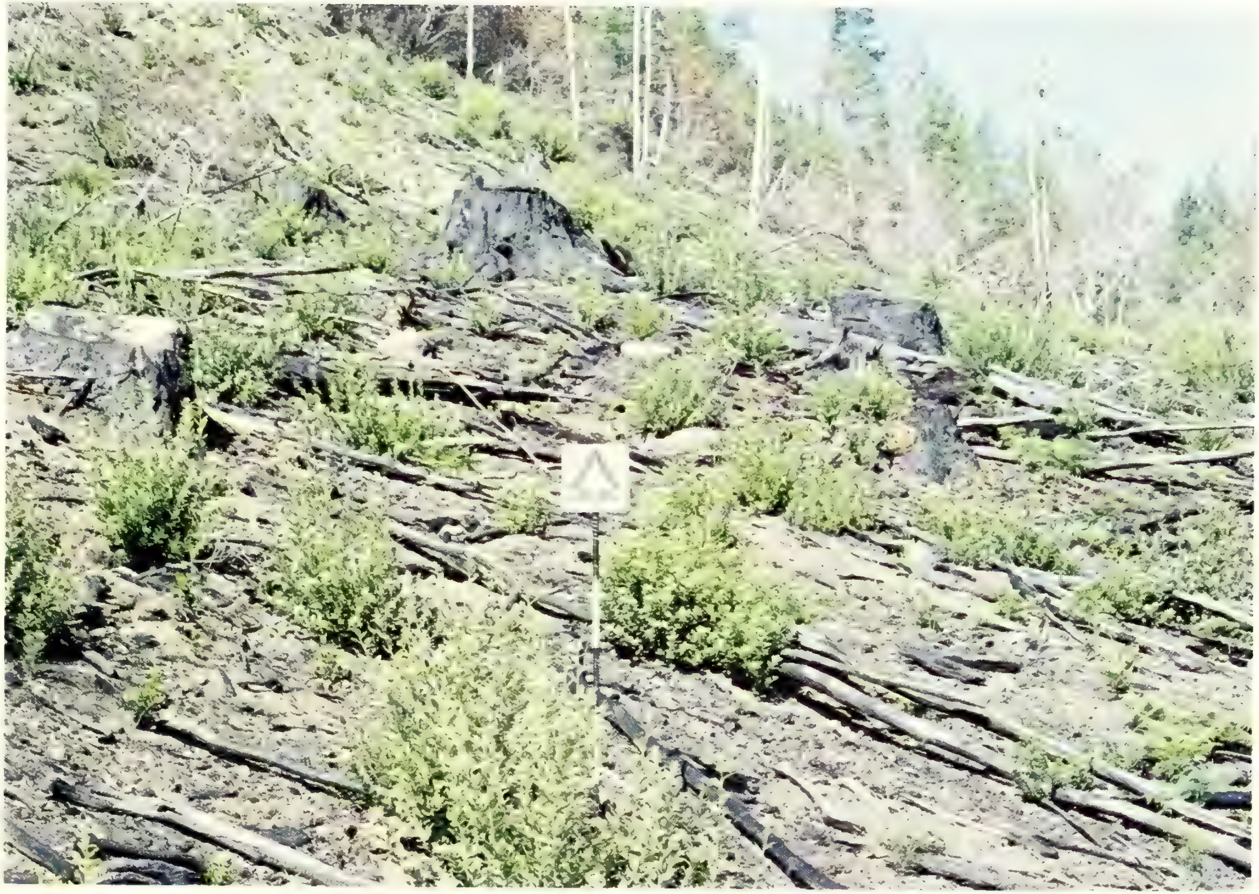
SIZE CLASS 4

CLEARCUT

A SERIES OF 7 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-DFHD-4-CC

DATA SHEET

Residue descriptive code 1-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.1	70
1.1-3.0	3.1	252
3.1-9.0	3.7	255
9.1-20.0	2.5	235
20.1+	0	0
Total	10.4	812

OTHER MEASUREMENTS

Average residue depth (feet) 0.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 55

Average duff and litter depth (inches) 0

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 32

tanoak (percent) 18

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 50

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 46.4

Net volume cruised (M fbm/acre) 33.3

Average stems/acre cut 30

Average d.b.h. of stems cut (inches) 35

Stand age (years) 250

Cutting prescription Clearcut

Yarding method High-lead

Slash treatment Spring broadcast burn

Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre

Stems remaining/acre

Basal area/acre before

Basal area/acre after

Average d.b.h. before (inches)

Average d.b.h. after (inches)

Thinning method

Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LM

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3C .

2-DFHD-4-CC

DATA SHEET

Residue descriptive code 2-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.0	132
1.1-3.0	5.1	405
3.1-9.0	8.8	577
9.1-20.0	2.6	176
20.1+	0	0
Total	18.5	1,290

OTHER MEASUREMENTS

Average residue depth	(feet)	0.2
Ground area covered by residue 1/4-inch diameter and larger	(percent)	61
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	95
tanoak	(percent)	5
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	40.0
Net volume cruised (M fbm/acre)	35.0
Average stems/acre cut	29
Average d.b.h. of stems cut (inches)	33
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	Spring broadcast burn
Period since cut or treatment (months)	7

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

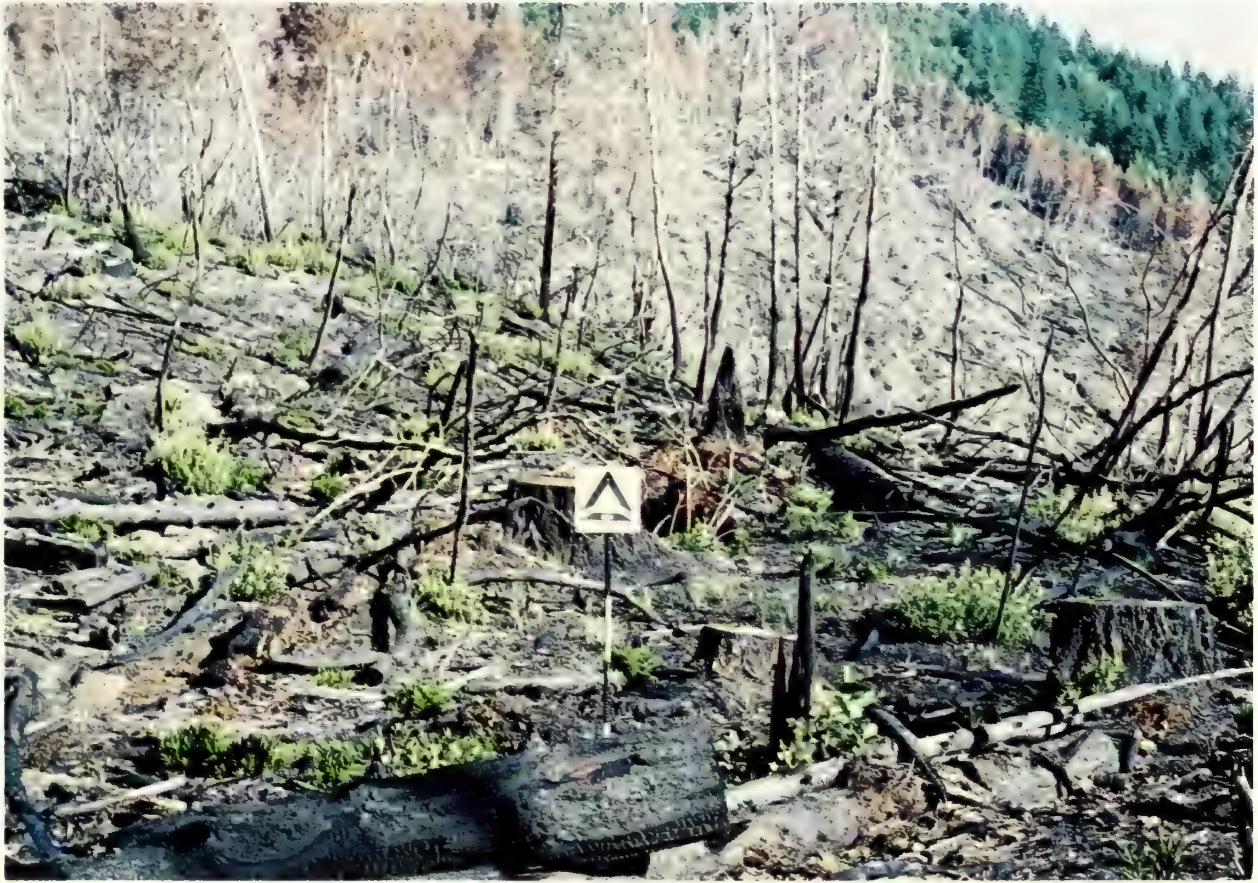
U.S. Forest Service Region 6 fuel type identification MM

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 2C.



3-DFHD-4-CC

DATA SHEET

Residue descriptive code 3-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.3	85
1.1-3.0	4.0	321
3.1-9.0	16.6	1,037
9.1-20.0	9.6	795
20.1+	6.8	530
Total	38.3	2,768

OTHER MEASUREMENTS

Average residue depth	(feet)	0.2
Ground area covered by residue 1/4-inch diameter and larger	(percent)	45
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	50
tanoak	(percent)	19
other	(percent)	1
Rotted residue 3.1-inch diameter and larger	(percent)	30

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	43.3
Net volume cruised (M fbm/acre)	36.7
Average stems/acre cut	29
Average d.b.h. of stems cut (inches)	12
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	Slackline
Slash treatment	Spring broadcast burn
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

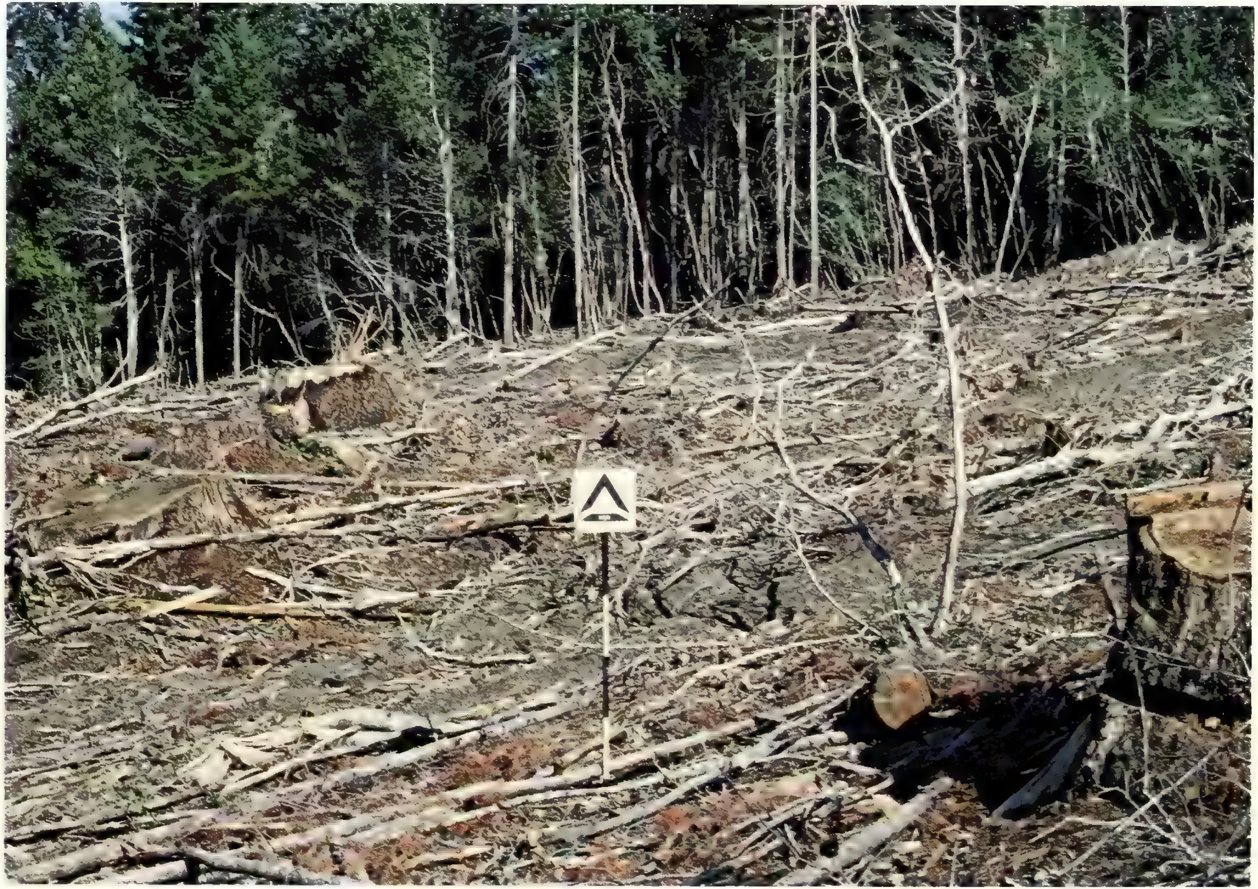
U.S. Forest Service Region 6 fuel type identification MM

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3C .



4-DFHD-4-CC

DATA SHEET

Residue descriptive code 4-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.7	244
1.1-3.0	6.3	502
3.1-9.0	15.3	968
9.1-20.0	12.8	828
20.1+	3.6	239
Total	41.7	2,781

OTHER MEASUREMENTS

Average residue depth	(feet)	0.5
Ground area covered by residue 1/4-inch diameter and larger	(percent)	81
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger Douglas-fir	(percent)	82
tanoak	(percent)	16
other	(percent)	1
Rotted residue 3.1-inch diameter and larger	(percent)	1

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	48.8
Net volume cruised (M fbm/acre)	42.3
Average stems/acre cut	37
Average d.b.h. of stems cut (inches)	31
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MM

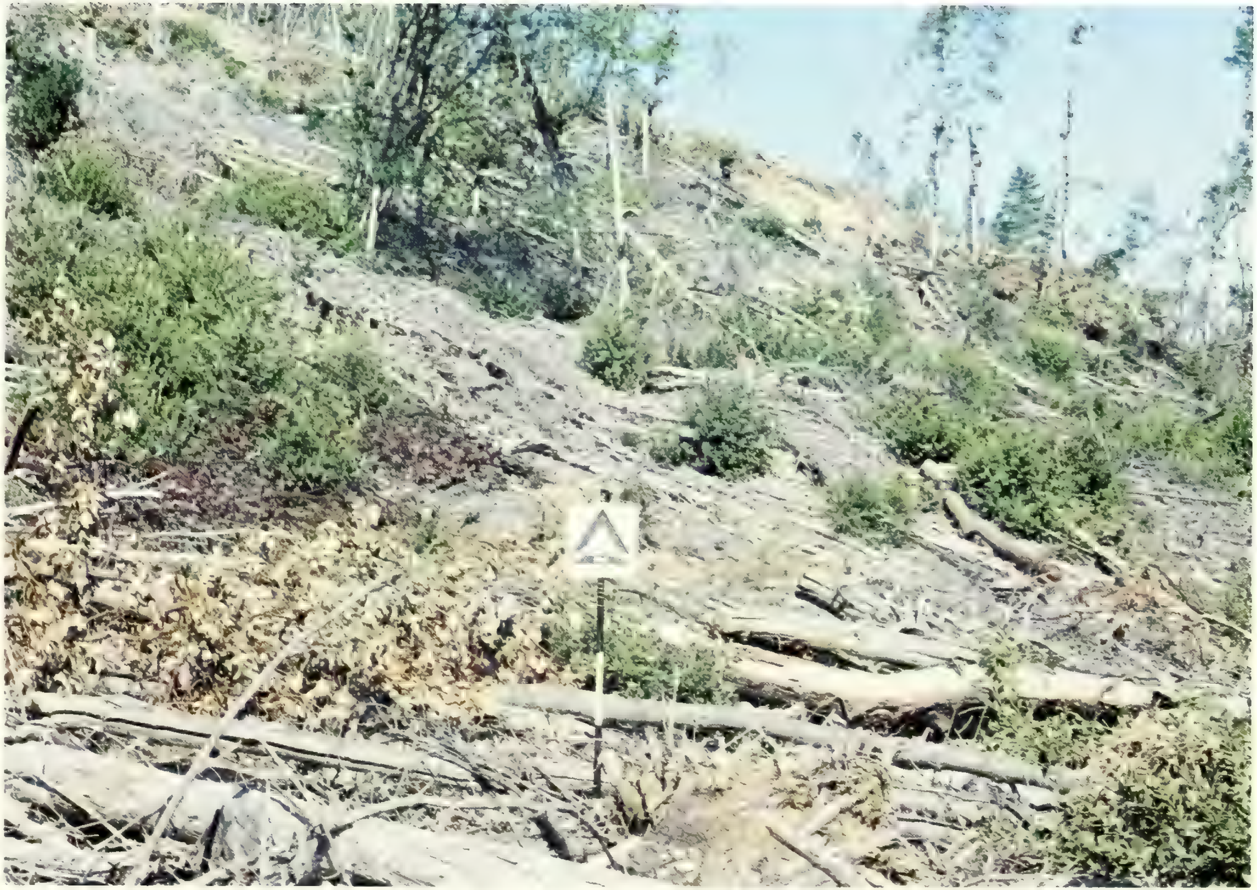
REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3B.

*Required yarding unmerchantable material (YUM) down to 8 inches, small end and 10 feet in length.



5-DFHD-4-CC

DATA SHEET

Residue descriptive code 5-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.7	179
1.1-3.0	4.8	386
3.1-9.0	37.8	2,045
9.1-20.0	24.8	1,233
20.1+	10.9	505
Total	81.0	4,348

OTHER MEASUREMENTS

Average residue depth	(feet)	0.8
Ground area covered by residue 1/4-inch diameter and larger	(percent)	83
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger tanoak	(percent)	54
madrone	(percent)	43
other	(percent)	3
Rotted residue 3.1-inch diameter and larger	(percent)	1

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	20.5
Net volume cruised (M fbm/acre)	18.4
Average stems/acre cut	119
Average d.b.h. of stems cut (inches)	18
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	High-lead
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3C.

6-DFHD-4-CC

DATA SHEET

Residue descriptive code 6-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	5.6	371
1.1-3.0	10.4	833
3.1-9.0	51.6	2,847
9.1-20.0	13.8	793
20.1+	0	0
Total	81.4	4,844

OTHER MEASUREMENTS

Average residue depth	(feet)	2.1
Ground area covered by residue 1/4-inch diameter and larger	(percent)	97
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger tanoak	(percent)	75
Douglas-fir	(percent)	12
other	(percent)	11
Rotted residue 3.1-inch diameter and larger	(percent)	2

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	43.5
Net volume cruised (M fbm/acre)	38.2
Average stems/acre cut	34
Average d.b.h. of stems cut (inches)	34
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	Slackline
Slash treatment	None
Period since cut or treatment (months)	12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

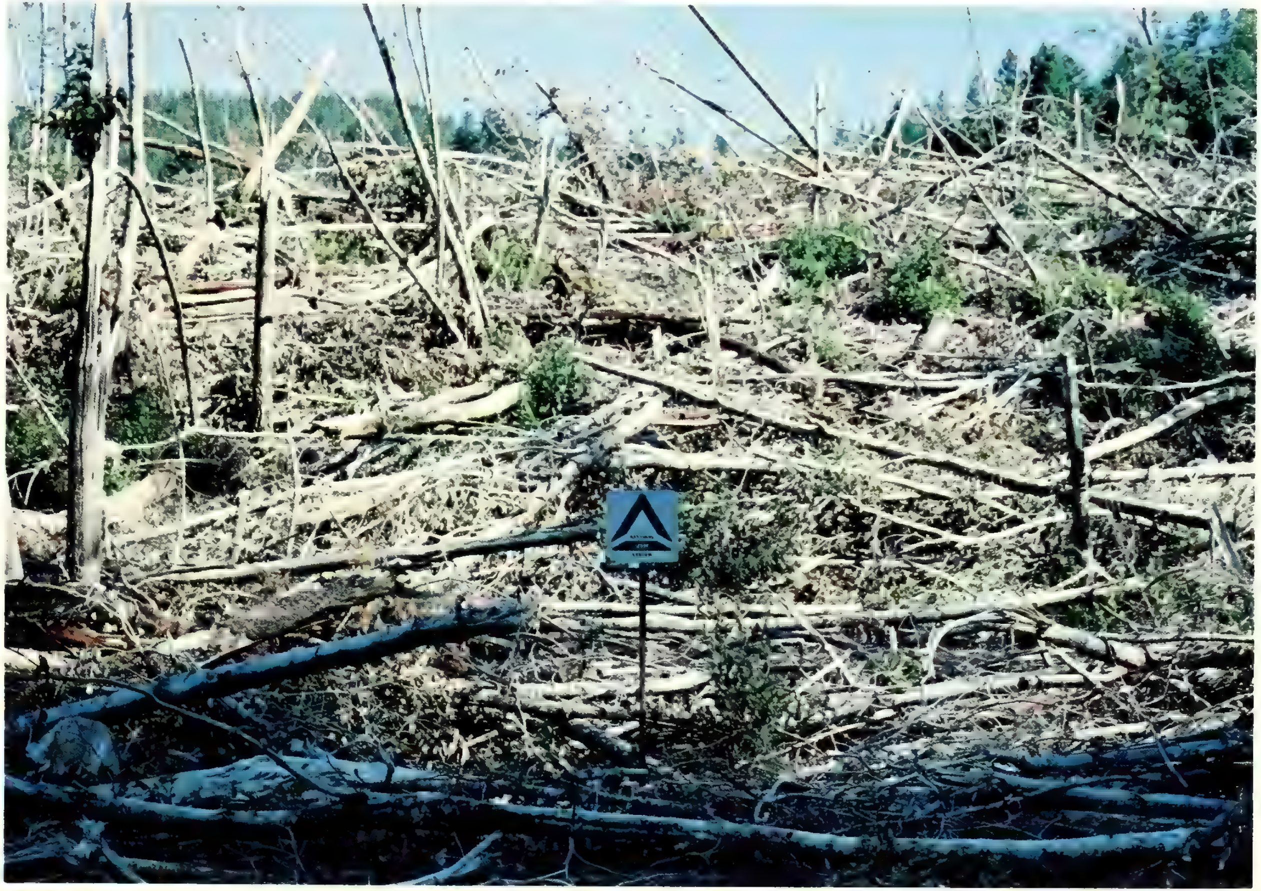
U.S. Forest Service Region 6 fuel type identification EE

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3C.



7-DFHD-4-CC

DATA SHEET

Residue descriptive code 7-DFHD-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	6.5	435
1.1-3.0	10.5	842
3.1-9.0	77.5	4,083
9.1-20.0	16.3	842
20.1+	0	0
Total	110.8	6,202

OTHER MEASUREMENTS

Average residue depth	(feet)	1.9
Ground area covered by residue 1/4-inch diameter and larger	(percent)	95
Average duff and litter depth	(inches)	0
Sound residue 3.1-inch diameter and larger madrone	(percent)	45
tanoak	(percent)	39
other	(percent)	14
Rotted residue 3.1-inch diameter and larger	(percent)	2

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	54.7
Net volume cruised (M fbm/acre)	46.6
Average stems/acre cut	34
Average d.b.h. of stems cut (inches)	31
Stand age (years)	200
Cutting prescription	Clearcut
Yarding method	Slackline
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification EE

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3C.

DOUGLAS-FIR–HARDWOOD

SIZE CLASS 4

PARTIAL CUT

A SERIES OF 6 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.

1-DFHD-4-PC

DATA SHEET

Residue descriptive code 1-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.7	49
1.1-3.0	3.4	270
3.1-9.0	4.0	227
9.1-20.0	4.2	415
20.1+	0	0
Total	12.3	961

OTHER MEASUREMENTS

Average residue depth		(feet)	0.1
Ground area covered by residue 1/4-inch diameter and larger		(percent)	40
Average duff and litter depth		(inches)	0.1
Sound residue 3.1-inch diameter and larger	madrone	(percent)	16
	Douglas-fir	(percent)	11
	other	(percent)	10
Rotted residue 3.1-inch diameter and larger		(percent)	63

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	20.3
Net volume cruised (M fbm/acre)	16.4
Average stems/acre cut	9
Average d.b.h. of stems cut (inches)	38
Stand age (years)	250+
Cutting prescription	Overstory removal
Yarding method	Rubber-tired skidder
Slash treatment	Machine piled
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

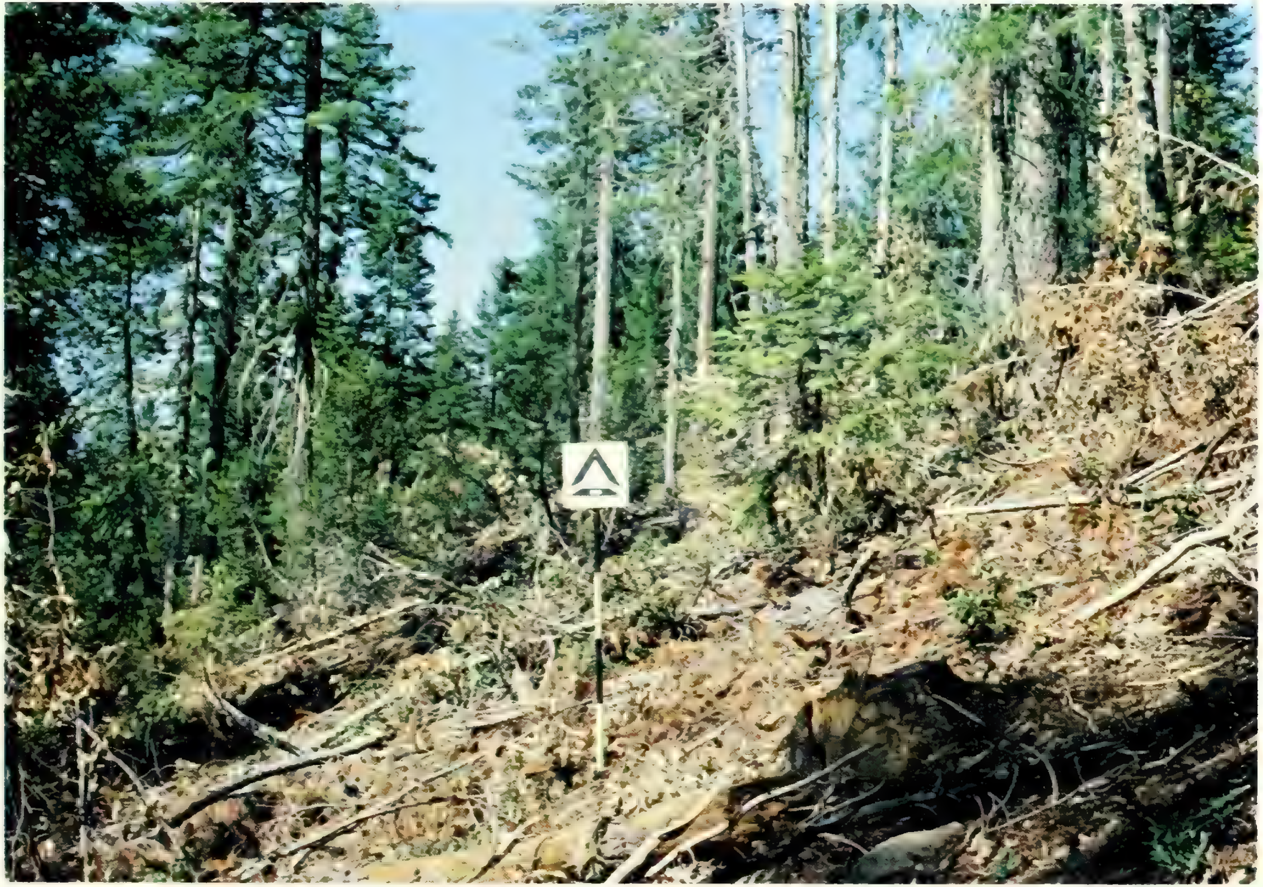
U.S. Forest Service Region 6 fuel type identification LL

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3A.



2-DFHD-4-PC

DATA SHEET

Residue descriptive code 2-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.0	132
1.1-3.0	8.7	693
3.1-9.0	5.1	409
9.1-20.0	2.8	235
20.1+	0	0
Total	18.6	1,469

OTHER MEASUREMENTS

Average residue depth (feet) 0.4

Ground area covered by residue 1/4-inch diameter and larger (percent) 69

Average duff and litter depth (inches) 0.4

Sound residue 3.1-inch diameter and larger western white pine (percent) 57

red fir (percent) 22

other (percent) 19

Rotted residue 3.1-inch diameter and larger (percent) 2

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 48.3

Net volume cruised (M fbm/acre) 37.5

Average stems/acre cut 20

Average d.b.h. of stems cut (inches) 34

Stand age (years) 250

Cutting prescription Shelterwood

Yarding method Skyline

Slash treatment YUM*

Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____

Stems remaining/acre ____

Basal area/acre before ____

Basal area/acre after ____

Average d.b.h. before (inches) ____

Average d.b.h. after (inches) ____

Thinning method ____

Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

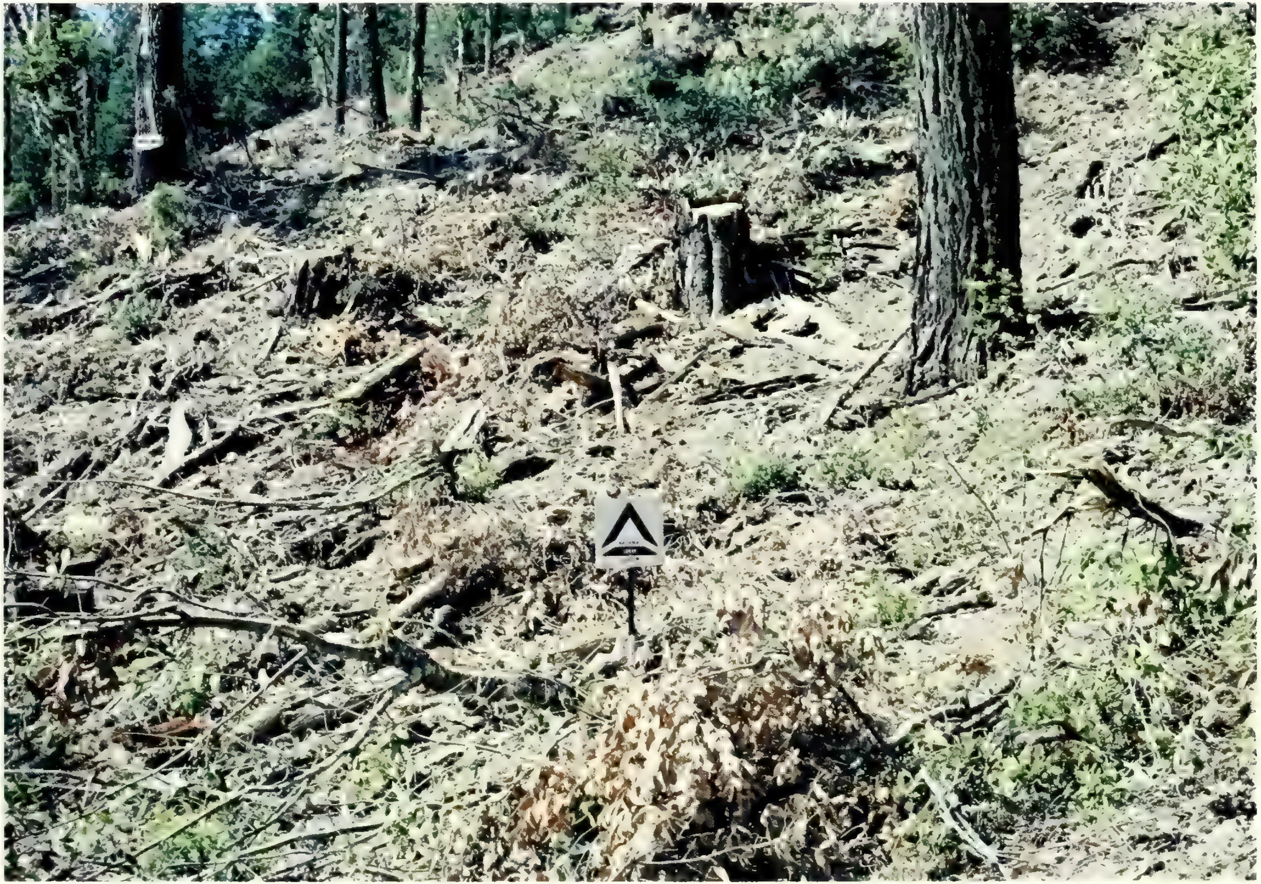
REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 2A.

*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end and 10 feet in length.



3-DFHD-4-PC

DATA SHEET

Residue descriptive code 3-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.7	116
1.1-3.0	8.7	693
3.1-9.0	16.9	1,237
9.1-20.0	8.1	730
20.1+	0	0
Total	35.4	2,776

OTHER MEASUREMENTS

Average residue depth	(feet)	0.5
Ground area covered by residue 1/4-inch diameter and larger	(percent)	72
Average duff and litter depth	(inches)	0.1
Sound residue 3.1-inch diameter and larger white fir	(percent)	51
tanoak	(percent)	19
other	(percent)	5
Rotted residue 3.1-inch diameter and larger	(percent)	25

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	35.4
Net volume cruised (M fbm/acre)	24.1
Average stems/acre cut	16
Average d.b.h. of stems cut (inches)	37
Stand age (years)	250+
Cutting prescription	Shelterwood
Yarding method	High-lead
Slash treatment	YUM*
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

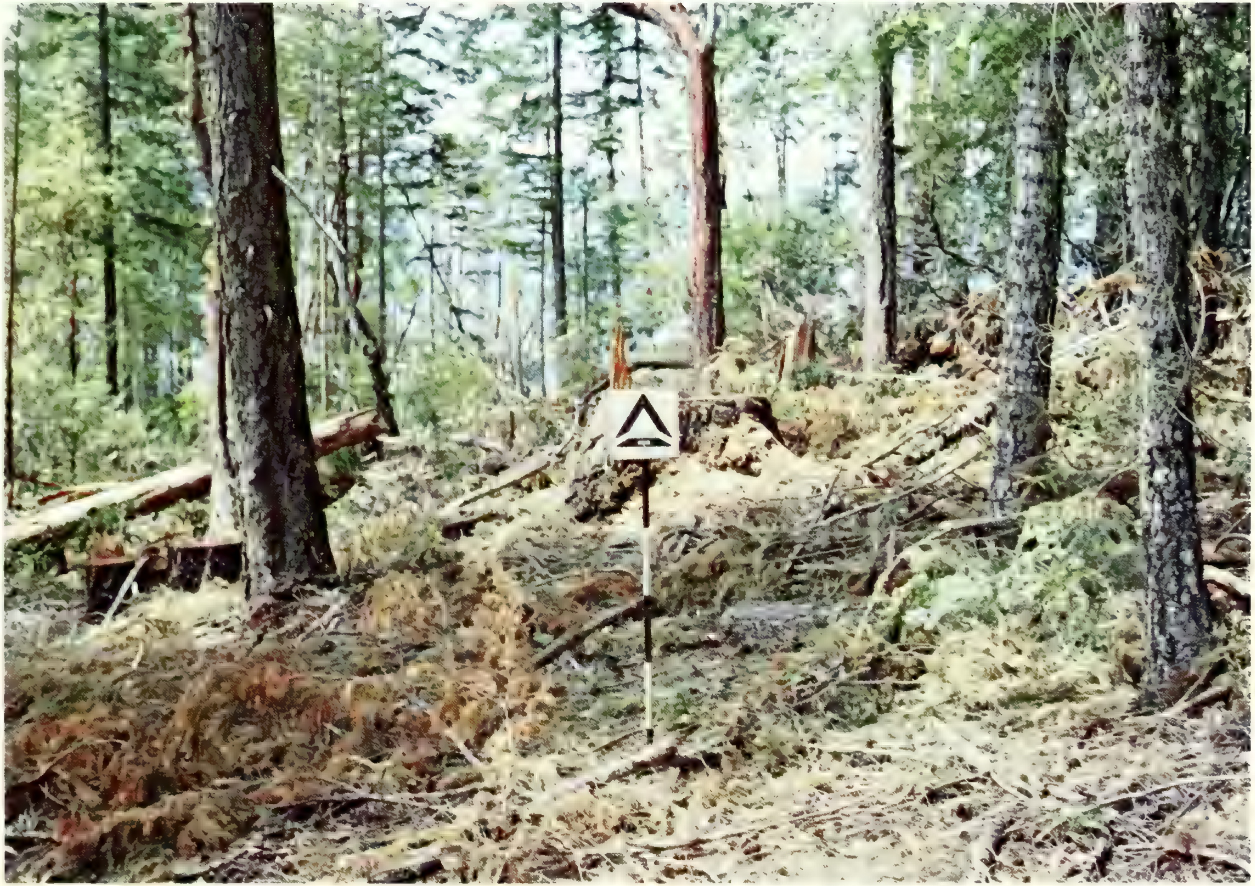
U.S. Forest Service Region 6 fuel type identification HM

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "
was rated by District Foresters as 3A.

*Required yarding unmerchantable material (YUM) down to 8 inches in diameter, small end and 10 feet in length.



4-DFHD-4-PC

DATA SHEET

Residue descriptive code 4-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	5.2	345
1.1-3.0	10.7	859
3.1-9.0	12.9	785
9.1-20.0	5.7	340
20.1+	8.0	532
Total	42.5	2,861

OTHER MEASUREMENTS

Average residue depth (feet) 1.3
Ground area covered by residue 1/4-inch diameter and larger (percent) 95
Average duff and litter depth (inches) 1.1
Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 78
madrone (percent) 16
other (percent) 4
Rotted residue 3.1-inch diameter and larger (percent) 2

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	37.4
Net volume cruised (M fbm/acre)	29.0
Average stems/acre cut	26
Average d.b.h. of stems cut (inches)	37
Stand age (years)	200+
Cutting prescription	Overstory removal
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 3B.

5-DFHD-4-PC

DATA SHEET

Residue descriptive code 5-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.0	198
1.1-3.0	8.8	703
3.1-9.0	29.8	1,781
9.1-20.0	5.8	397
20.1+	33.2	2,720
Total	80.6	5,799

OTHER MEASUREMENTS

Average residue depth	(feet)	0.5
Ground area covered by residue 1/4-inch diameter and larger	(percent)	85
Average duff and litter depth	(inches)	1.2
Sound residue 3.1-inch diameter and larger madrone	(percent)	25
Douglas-fir	(percent)	19
other	(percent)	22
Rotted residue 3.1-inch diameter and larger	(percent)	34

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	35.2
Net volume cruised (M fbm/acre)	26.6
Average stems/acre cut	62
Average d.b.h. of stems cut (inches)	26
Stand age (years)	150
Cutting prescription	Tree selection
Yarding method	Mobile yarder
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 2C.

6-DFHD-4-PC

DATA SHEET

Residue descriptive code 6-DFHD-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.5	166
1.1-3.0	8.7	693
3.1-9.0	14.0	1,055
9.1-20.0	31.4	2,413
20.1+	34.2	2,506
Total	90.8	6,833

OTHER MEASUREMENTS

Average residue depth (feet) 0.6

Ground area covered by residue 1/4-inch diameter and larger (percent) 76

Average duff and litter depth (inches) 0.3

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 57

Port-Orford-cedar (percent) 18

______ (percent) ___

Rotted residue 3.1-inch diameter and larger (percent) 25

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 37.4

Net volume cruised (M fbm/acre) 30.9

Average stems/acre cut 10

Average d.b.h. of stems cut (inches) 45

Stand age (years) 200+

Cutting prescription Overstory removal

Yarding method Tractor

Slash treatment None

Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ___

Stems remaining/acre ___

Basal area/acre before ___

Basal area/acre after ___

Average d.b.h. before (inches) ___

Average d.b.h. after (inches) ___

Thinning method ___

Slash treatment ___

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Down and dead hardwoods comprise much of the residue in this photo series level. The understory hardwood stand prior to logging, using rating criteria where:

1 = <5 ft in height
2 = 5-15 ft in height
3 = >15 ft in height
and
A = 0-33% understory crown space occupied
B = 34-66% " " " "
C = 67-100% " " " "

was rated by District Foresters as 1A.

GPO 697-498

The mission of the PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

Fairbanks, Alaska
Juneau, Alaska
Bend, Oregon
Corvallis, Oregon
La Grande, Oregon
Portland, Oregon
Olympia, Washington
Seattle, Washington
Wenatchee, Washington

Mailing address: Pacific Northwest Forest and Range
Experiment Station
P.O. Box 3141
Portland, Oregon 97208

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USDA FOREST SERVICE GENERAL TECHNICAL REPORT PNW-52
1976

PHOTO SERIES FOR QUANTIFYING FOREST RESIDUES IN THE:

PONDEROSA PINE TYPE
PONDEROSA PINE AND ASSOCIATED SPECIES TYPE
LODGEPOLE PINE TYPE

WAYNE G. MAXWELL
FRANKLIN R. WARD

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PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
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FOREST SERVICE
PORTLAND, OREGON

ABSTRACT

Six series of photographs display different forest residue loading levels, by size classes, for areas of like timber type and cutting practice.

Information with each photo includes measured weights, volumes and other residue data, information about the timber stand and harvest or thinning actions, and fuel ratings.

These photo series provide a fast and easy-to-use means for quantifying and describing existing and expected residues.

KEYWORDS: Residue (forest), residue management, fuel (waste wood), slash (ponderosa pine) (lodgepole pine), management (forest), forest residues estimation.

COOPERATIVE ACKNOWLEDGMENT

This publication was developed by the Pacific Northwest Forest and Range Experiment Station, Forest Service, U.S. Department of Agriculture, in cooperation with the Bureau of Land Management, U.S. Department of the Interior; Washington State Department of Natural Resources; State of Oregon Forestry Department; and U.S. Forest Service, Region 6, to serve the needs of forest land managers in the Pacific Northwest.

LIST OF PLANT SPECIES CITED

Douglas-fir	*Pseudotsuga menziesii* (Mirb.) Franco
lodgepole pine	*Pinus contorta* Dougl.
ponderosa pine	*Pinus ponderosa* Laws.
subalpine fir	*Abies lasiocarpa* (Hook.) Nutt.
western larch	*Larix occidentalis* Nutt.
white fir	*Abies concolor* (Gord. & Glend.) Lindl.

METRIC CONVERSIONS

1 acre = 0.4047 hectare
2.471 acres = 1 hectare
1 cubic foot = 0.02832 cubic meter
35.31 cubic feet = 1 cubic meter
1 foot = 0.3048 meter
3.281 feet = 1 meter
1 inch = 2.54 centimeters
0.3937 inch = 1 centimeter
1 ton (short) = 0.907 ton (metric)
1.102 tons (short) = 1 ton (metric)

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WHAT ARE THESE PHOTO SERIES?

These photo series are arrays of photos, with each array showing different residue loading levels generated from like timber types and cutting practices. Each photo is supplemented with information which includes:

- Measured quantities by size classes, average depth, ground area covered, and other residue data.
- Harvesting or thinning information.
- Fuel ratings.

Thus, the series provide a basis for quantifying and describing existing and expected residue loadings on other areas and serve as a communication link between users.

WHY ARE THEY NEEDED?

Timber harvesting, silvicultural practices, and land clearing operations annually generate forest residues on millions of acres in the Western United States where these photo series may have application. Projected increase in demand for wood products and the trend away from clearcutting practices will increase this acreage if the cut remains constant or increases.

Although some residues are beneficial for such purposes as nutrient cycling, soil protection, wildlife cover, and microclimate effect, excessive residues adversely affect the forest environment in many ways. Much of the forest contains residues in undetermined but excessive quantities from the standpoints of resource use, protection, and management. To reduce residues to a level considered desirable, estimates are needed on quantities that now exist or will be created by some activity.

Inventory techniques, such as the planar intersect method, are very useful when a high degree of accuracy is needed but are time consuming and costly to apply extensively. Photo series can be used to make fast, easy, and inexpensive quantifications of residue, adequate for most management needs.

There has been no way for all resource disciplines to become readily familiar with residue volumes and descriptions so that they can make quantitative inputs to residue management. Likewise, because fuel rating systems are specialized and subjective, they too are not readily adapted to other environmental components. These deficiencies can be overcome with the photo series.

HOW CAN THEY BE USED?

Inventory of Down Residue

Loadings in various residue size classes, average residue depth, and ground area covered are characteristics that are visible in the photographs: hence, users can estimate any of these characteristics on an area being inventoried by comparing them with the photos as follows:

1. Observe each characteristic of the residue on the ground (e.g., 3.1- to 9-inch loading).
2. Select a photo which nearly matches, or photos that bracket, the observed characteristic.
3. Obtain the quantitative value for the characteristic being estimated from the data sheet accompanying the selected photo (or interpolate a value between photos).

These steps are repeated for each characteristic desired. If the general area being inventoried has zones of obvious differences in residue loading, the user should consider making separate determinations for each zone, which can then be weighted and cumulated for the whole area.

Residue characteristics not distinguishable in the photographs are duff and litter depth, proportion of sound residue by species, and proportion rotted. If values for these characteristics are desired in an inventory, they must be derived from independent sampling or observations.

Inventory information can be used by land managers to (1) evaluate impacts residues have on various aspects of forest management, (2) identify areas of unacceptable residue loading, (3) identify priority areas for treatment, (4) estimate amount of utilizable material, and (5) predict fire behavior characteristics.

Determination of Desired Residue Level

Land management objectives can be more nearly achieved if a team of appropriate specialists can participate in specifying residues which should remain on site after completion of a cutting activity. Individuals helping with these determinations can study the photo series to recognize the appearance of various quantities and distributions of residue. With this knowledge, each individual can describe in quantitative terms the residue he believes should be retained to meet environmental concerns and goals of his particular specialty. The group can then use the photo series as a communication tool to resolve differences in arriving at a desired level.

After treatment, the degree to which objectives were achieved can be judged by comparing observed posttreatment loading with the desired level description.

Prediction of Residues From Planned Cutting and Residue Changes From Treatments

Photo series are a rudimentary aid for predicting amounts of residue from cutting and residue changes from treatments. Many factors, such as condition of timber stand, topography, logging method, and utilization intensity, affect the volume of resulting residues, so users should bear in mind that these series depict only a few of the possible combinations.

To predict residue volumes from planned cutting, the user compares timber volume and size information from cutting plans with this kind of information in the photo series. Selecting a photo series level or levels with similar stand characteristics, the user refers to data sheet loadings, considers factors which differ from the photo series situations, and quantifies the loading expected.

Predicted loadings can be used to support changes in cutting and removal actions and to plan appropriate treatments.

To predict residue changes from treatments, the user studies the treated and untreated levels in the photo series to gain knowledge of relative changes or reductions affected by sample treatments. Then, comparing residue inventory or preharvest prediction information with levels in the series, the user determines the change a specific treatment may produce.

Predicted change in residue from treatments can aid in (1) identifying treatments that will reduce residues to the desired level, (2) selecting the most cost-effective treatments, and (3) estimating tons that will be consumed by fire. Improved accuracy in estimating tons consumed by fire will increase reliability of particulate and chemical compound emission calculations.

HOW WERE THEY DEVELOPED?

Areas photographed for these series were selected to show typical residue loading variations resulting from commonly applied harvest and cultural practices in major vegetative types of the inland Pacific Northwest. Photos were taken and data collected as follows:

1. Areas were photographed and the material in the photo area sampled in accordance with U.S. Forest Service national guidelines.[1]

2. Measurement technique was in accordance with the "Handbook for Inventorying Downed Woody Material."[2]

3. Timber stand, logging, and residue treatment information was obtained from timber sale or project records in field offices.

4. Forest Service Region 6 fuel types were assigned by a panel of Forest Service fuel specialists.[3]

---

[1] USDA Forest Service. 1975. National fuel classification and inventory system, preliminary draft. 61 p., illus. Washington Office, Washington, D.C.

[2] Brown, James K. 1974. Handbook for inventorying downed woody material. USDA For. Serv. Gen. Tech. Rep. INT-16, 24 p., illus. Intermt. For. and Range Exp. Stn., Ogden, Utah.

[3] USDA Forest Service Region 6. 1968. Guide for fuel type identification. 48 p., illus. Portland, Oreg.

HOW CAN THEY BE SUPPLEMENTED?

If users in the inland Pacific Northwest find they have important local residue loadings which are not adequately represented, they can supplement these series or develop additional series by following procedures described in the reference documents. The series in this publication may be usable, in total or in part, in appropriate vegetative types in other regions.

These series do not show residue loadings in stands undisturbed by cutting activities. Natural residue photo series may be developed in the future to aid in inventorying such areas.

A companion publication by the Pacific Northwest Forest and Range Experiment Station, containing photo series for use in coastal Douglas-fir--hemlock and coastal Douglas-fir--hardwood types, has been published.[4]

HOW ARE LEVELS IN THESE SERIES CODED?

The data for each level are presented on the page facing the photo. Facing picture and data pages have the same code for the residue situation shown. The code shows:

---

[4] Maxwell, Wayne G., and Franklin R. Ward. 1976. Photo series for quantifying forest residues in the: coastal Douglas-fir--hemlock type, coastal Douglas-fir--hardwood type. USDA For. Serv. Gen. Tech. Rep. PNW-51, 103 p., illus. Pac. Northwest For. and Range Exp. Stn., Portland, Oreg.

a. Order of rank from lightest loading to heaviest loading in the series of photographs.

b. Forest type, e.g., PP = ponderosa pine, PP&ASSOC = ponderosa pine and associated species, LP = lodgepole pine.

c. Forest size class, where:
1 = <5-inch d.b.h.

2 = 5- to 11-inch d.b.h.

3 = 12- to 20-inch d.b.h.

4 = >20-inch d.b.h.

d. Cutting practice, where:

CC = clearcut

PC = partial cut (shelterwood, selection, overstory removal)

TH = precommercial thinning

Example: 1-PP-4-CC is the first photo in the series for ponderosa pine, >20-inch diameter trees, after harvest by clearcutting.

PONDEROSA PINE

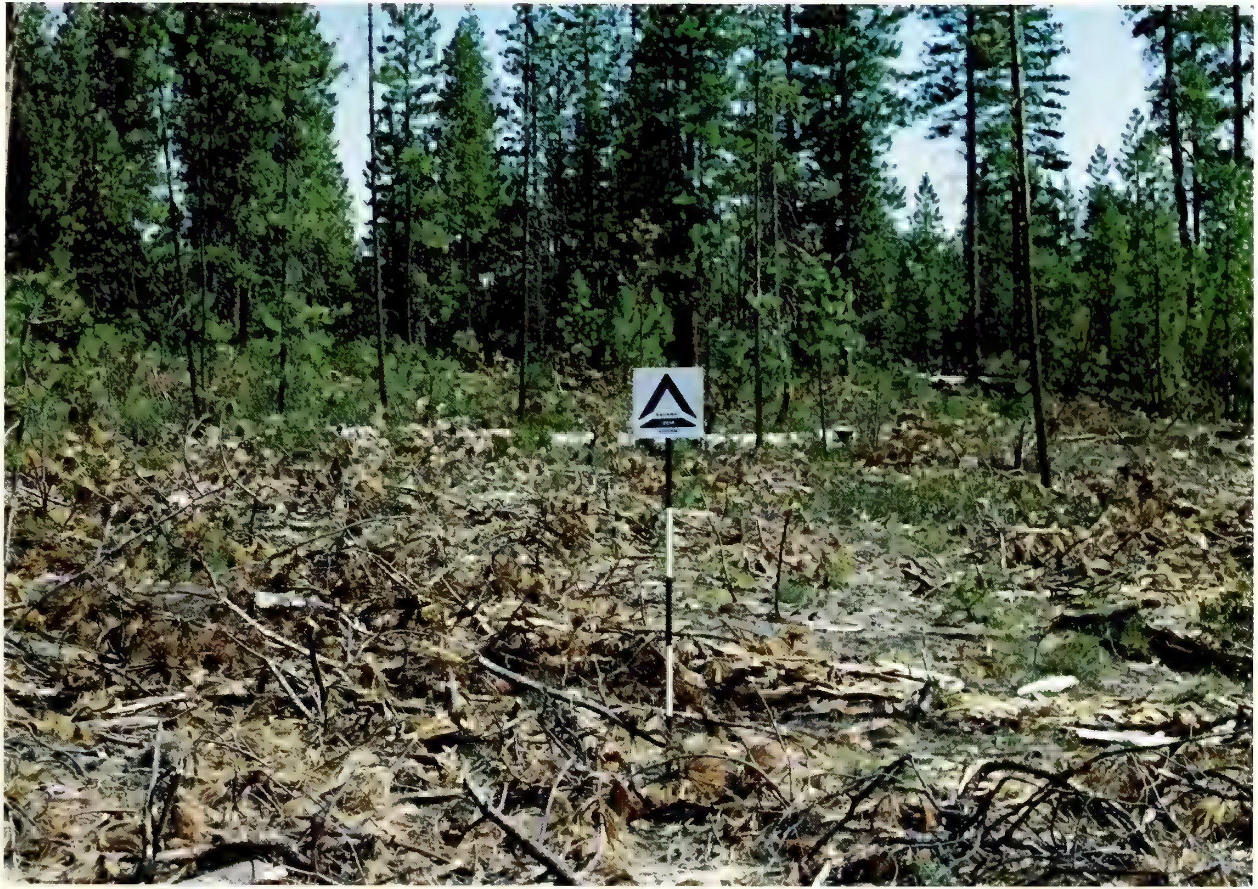
SIZE CLASS 4

CLEARCUT

A SERIES OF 2 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-PP-4-CC

DATA SHEET

Residue descriptive code 1-PP-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.9	235
1.1-3.0	6.7	439
3.1-9.0	5.3	430
9.1-20.0	3.1	332
20.1+	3.3	260
Total	22.3	1,696

OTHER MEASUREMENTS

Average residue depth (feet) 0.3
Ground area covered by residue 1/4-inch diameter and larger (percent) 75
Average duff and litter depth (inches) 0.8
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 66
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 34

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 18.1
Net volume cruised (M fbm/acre) 15.9
Average stems/acre cut 18
Average d.b.h. of stems cut (inches) 34
Stand age (years) 250+
Cutting prescription Clearcut
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

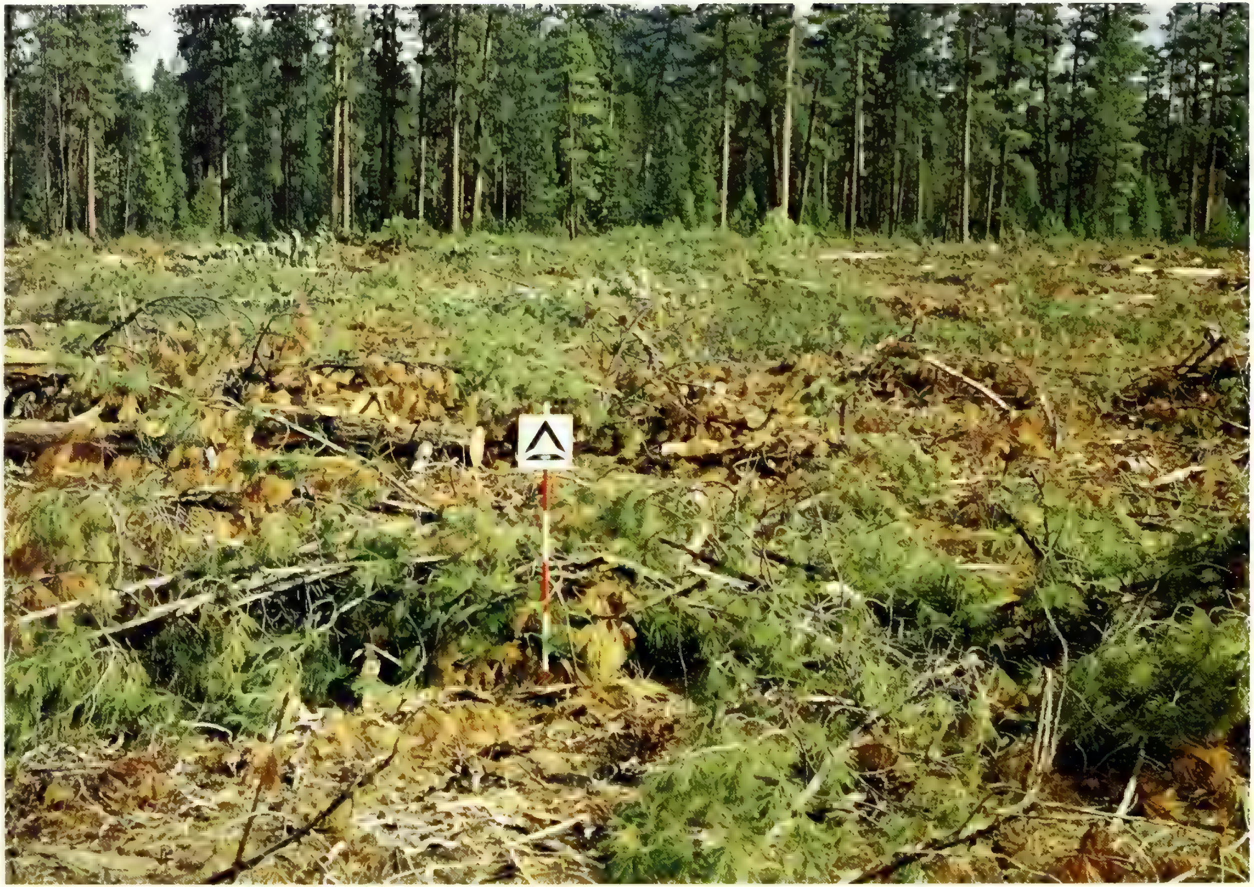
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HM

REMARKS



2-PP-4-CC

DATA SHEET

Residue descriptive code 2-PP-4-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	8.1	492
1.1-3.0	8.1	530
3.1-9.0	6.3	517
9.1-20.0	17.2	1,375
20.1+	6.6	529
Total	46.3	3,443

OTHER MEASUREMENTS

Average residue depth	(feet)	0.7
Ground area covered by residue 1/4-inch diameter and larger	(percent)	77
Average duff and litter depth	(inches)	0.7
Sound residue 3.1-inch diameter and larger ponderosa pine	(percent)	96
lodgepole pine	(percent)	1
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	3

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)	13.0
Net volume cruised(M fbm/acre)	11.5
Average stems/acre cut	60
Average d.b.h. of stems cut (inches)	22
Stand age (years)	200+
Cutting prescription	Clearcut
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre _____
Stems remaining/acre _____
Basal area/acre before _____
Basal area/acre after _____
Average d.b.h. before (inches) _____
Average d.b.h. after (inches) _____
Thinning method _____
Slash treatment _____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification EH

REMARKS

PONDEROSA PINE

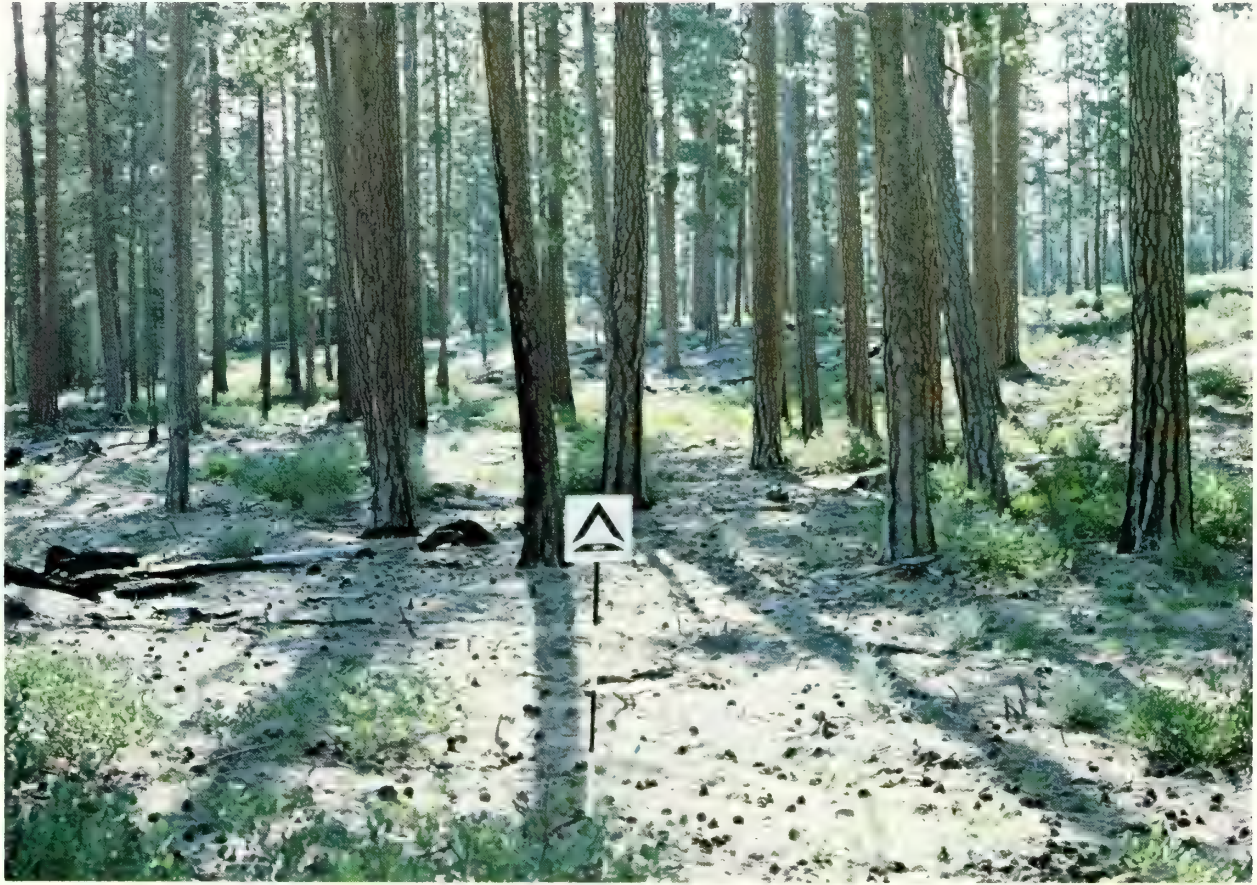
SIZE CLASS 4

PARTIAL CUT

A SERIES OF 5 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-PP-4-PC

DATA SHEET

Residue descriptive code 1-PP-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.4	25
1.1-3.0	1.8	119
3.1-9.0	0.5	40
9.1-20.0	0	0
20.1+	0	0
Total	2.7	184

OTHER MEASUREMENTS

Average residue depth (feet) 0.04

Ground area covered by residue 1/4-inch diameter and larger (percent) 16

Average duff and litter depth (inches) 0.7

Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 100

________ (percent) ____

________ (percent) ____

Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	16.0
Net volume cruised (M fbm/acre)	15.0
Average stems/acre cut	15
Average d.b.h. of stems cut (inches)	29
Stand age (years)	300+
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	24

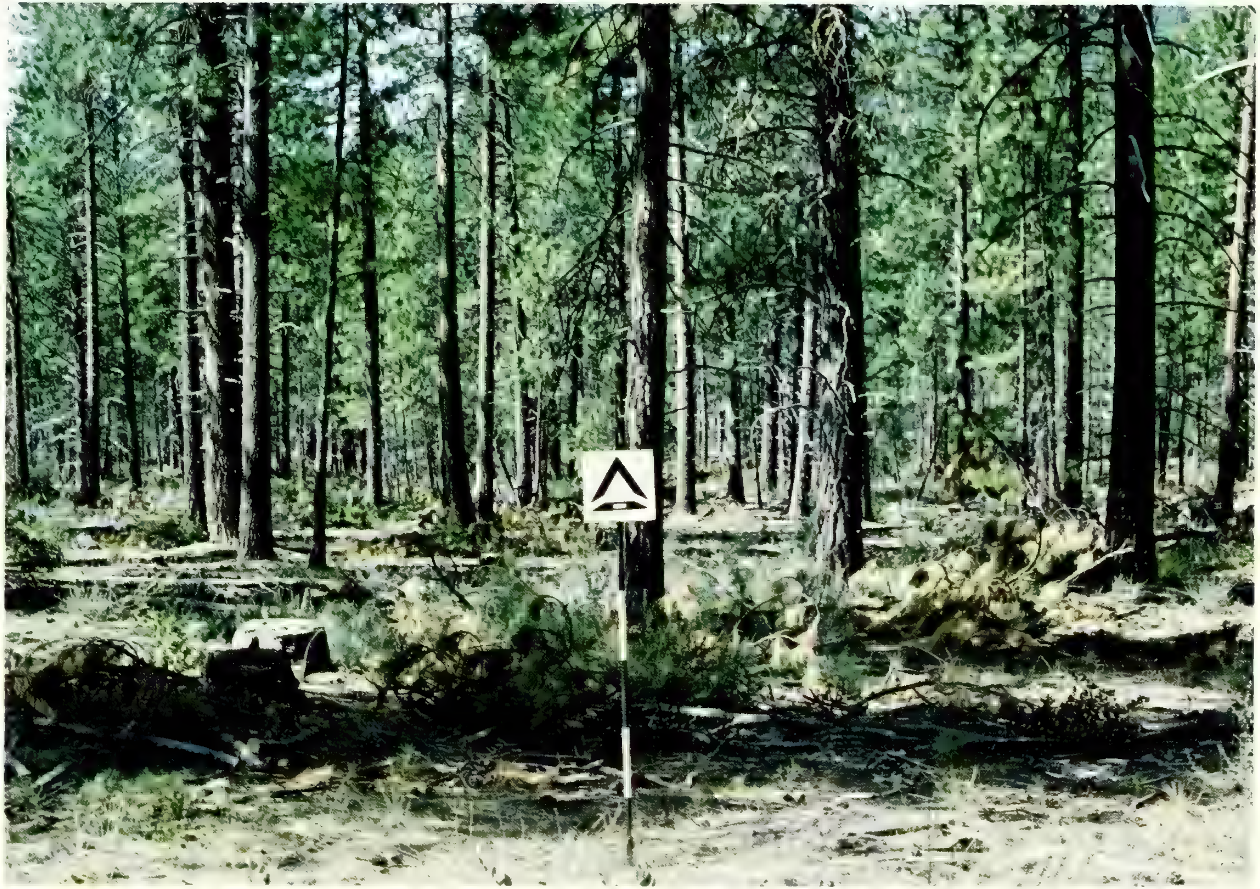
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



2-PP-4-PC

DATA SHEET

Residue descriptive code 2-PP-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.2	132
1.1-3.0	3.4	220
3.1-9.0	2.9	234
9.1-20.0	0	0
20.1+	0	0
Total	8.5	586

OTHER MEASUREMENTS

Average residue depth (feet) 0.2
Ground area covered by residue 1/4-inch diameter and larger (percent) 43
Average duff and litter depth (inches) 0.8
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 100
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 3.6
Net volume cruised (M fbm/acre) 3.4
Average stems/acre cut 17
Average d.b.h. of stems cut (inches) 16
Stand age (years) 110
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

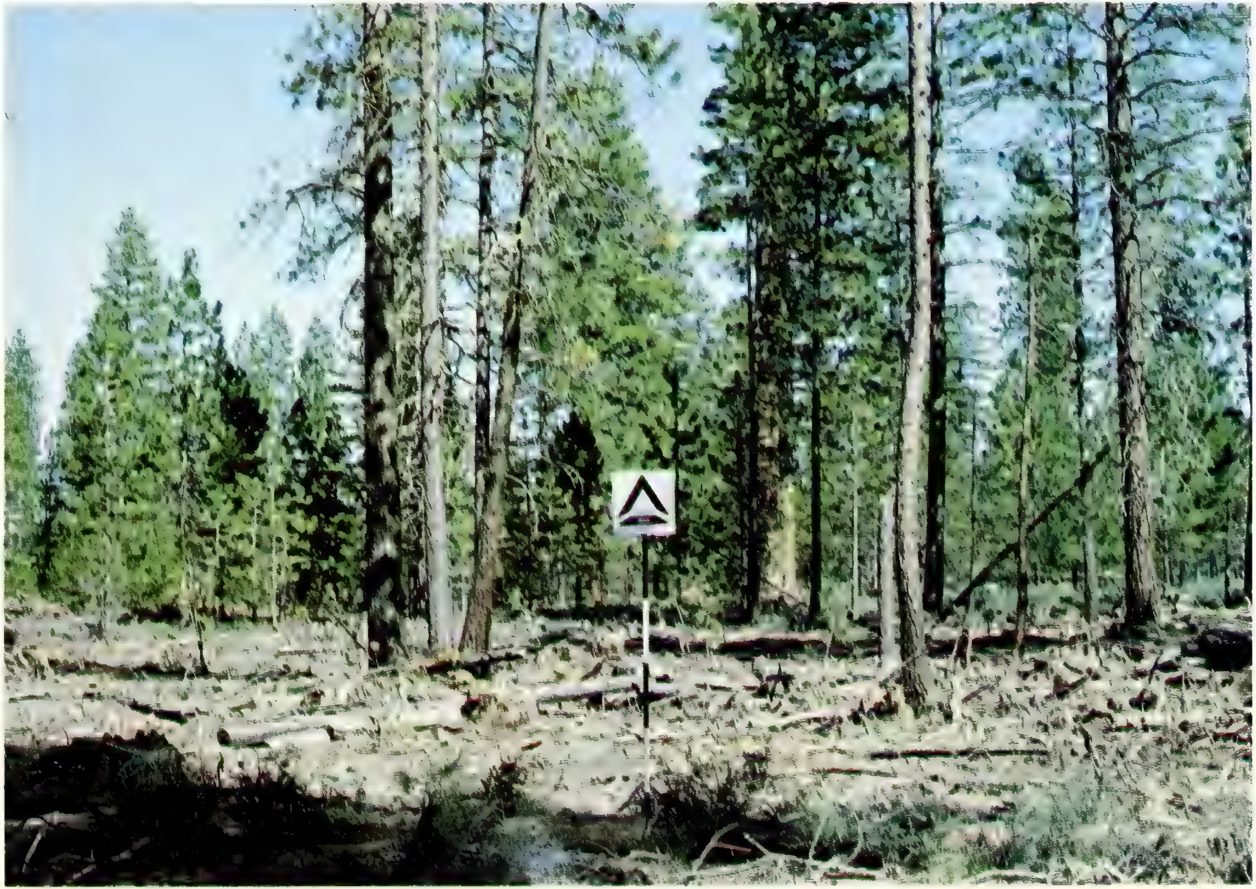
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification ML

REMARKS



3-PP-4-PC

DATA SHEET

Residue descriptive code 3-PP-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.7	164
1.1-3.0	5.0	324
3.1-9.0	5.7	456
9.1-20.0	0	0
20.1+	0	0
Total	13.4	944

OTHER MEASUREMENTS

Average residue depth (feet) 0.3
Ground area covered by residue 1/4-inch diameter and larger (percent) 67
Average duff and litter depth (inches) 0.6
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 100
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 4.7
Net volume cruised(M fbm/acre) 4.6
Average stems/acre cut 30
Average d.b.h. of stems cut (inches) 20
Stand age (years) 200+
Cutting prescription Shelterwood
Yarding method Rubber-tired skidder
Slash treatment None
Period since cut or treatment (months) 24

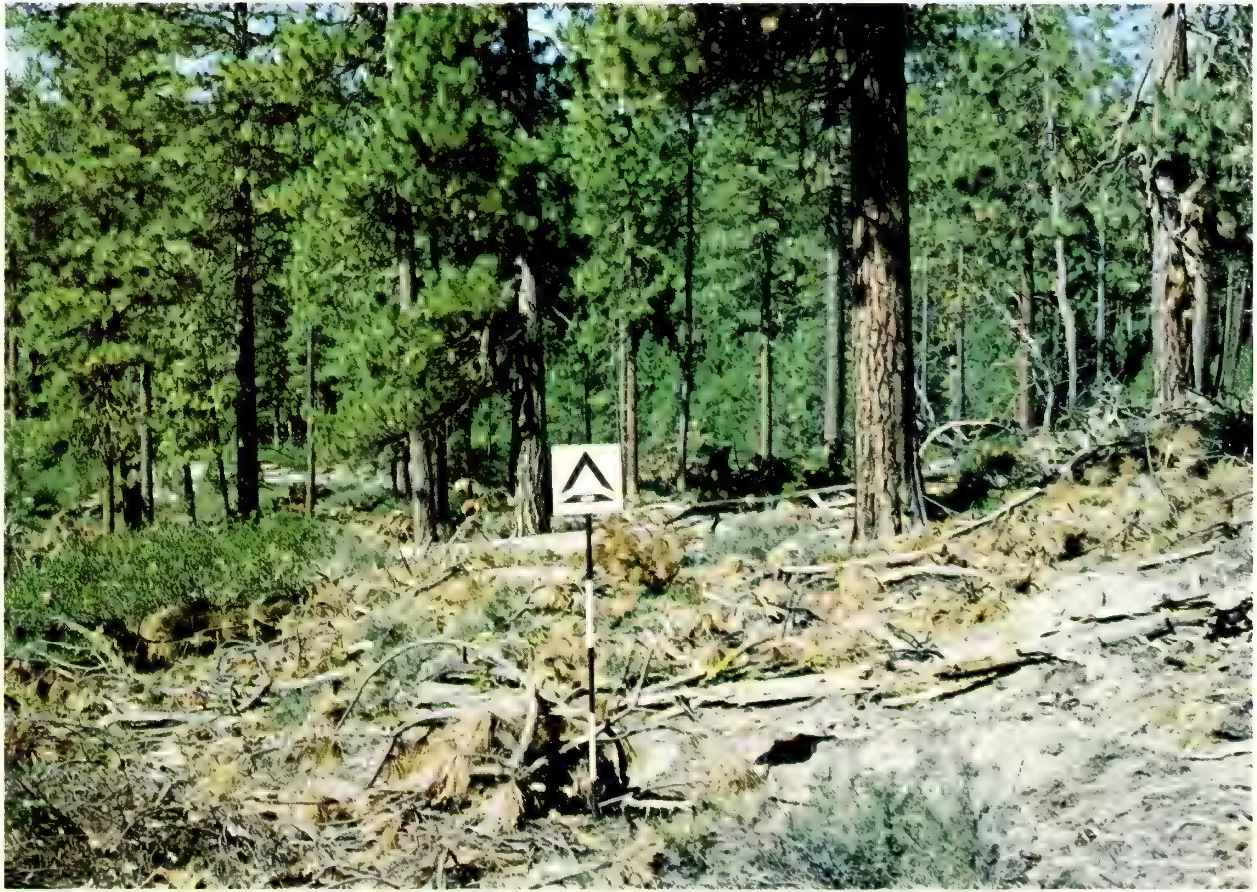
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



4-PP-4-PC

DATA SHEET

Residue descriptive code 4-PP-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.3	139
1.1-3.0	4.8	315
3.1-9.0	4.3	341
9.1-20.0	8.2	655
20.1+	2.5	200
Total	22.1	1,650

OTHER MEASUREMENTS

Average residue depth (feet) 0.3
Ground area covered by residue 1/4-inch diameter and larger (percent) 61
Average duff and litter depth (inches) 1.0
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 100
________ (percent) ____
________ (percent) ____
Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 5.5
Net volume cruised (M fbm/acre) 5.4
Average stems/acre cut 15
Average d.b.h. of stems cut (inches) 20
Stand age (years) 200+
Cutting prescription Shelterwood
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

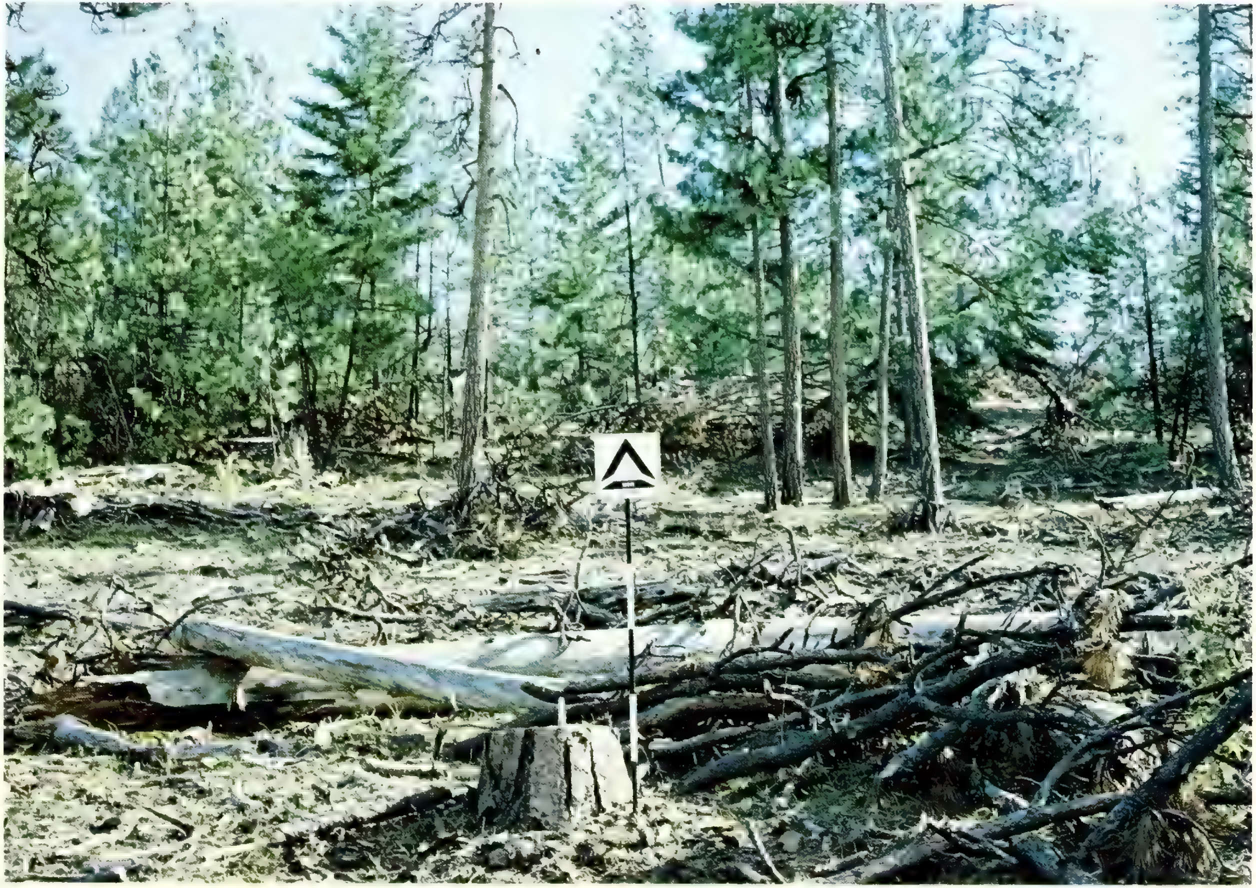
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____
Stems remaining/acre ____
Basal area/acre before ____
Basal area/acre after ____
Average d.b.h. before (inches) ____
Average d.b.h. after (inches) ____
Thinning method ____
Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS



5-PP-4-PC

DATA SHEET

Residue descriptive code 5-PP-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.8	231
1.1-3.0	7.4	482
3.1-9.0	7.1	575
9.1-20.0	4.6	410
20.1+	6.6	531
Total	29.5	2,229

OTHER MEASUREMENTS

Average residue depth (feet) 0.3
Ground area covered by residue 1/4-inch diameter and larger (percent) 77
Average duff and litter depth (inches) 1.2
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 89
______ (percent) ___
______ (percent) ___
Rotted residue 3.1-inch diameter and larger (percent) 11

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) ___
Net volume cruised(M fbm/acre) [1/]9.5
Average stems/acre cut 20
Average d.b.h. of stems cut (inches) 18
Stand age (years) 70
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) 24

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ___
Stems remaining/acre ___
Basal area/acre before ___
Basal area/acre after ___
Average d.b.h. before (inches) ___
Average d.b.h. after (inches) ___
Thinning method ___
Slash treatment ___

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MM

REMARKS

Area not cruised. Timber sold on a net scale basis.

[1/] See remarks.

PONDEROSA PINE

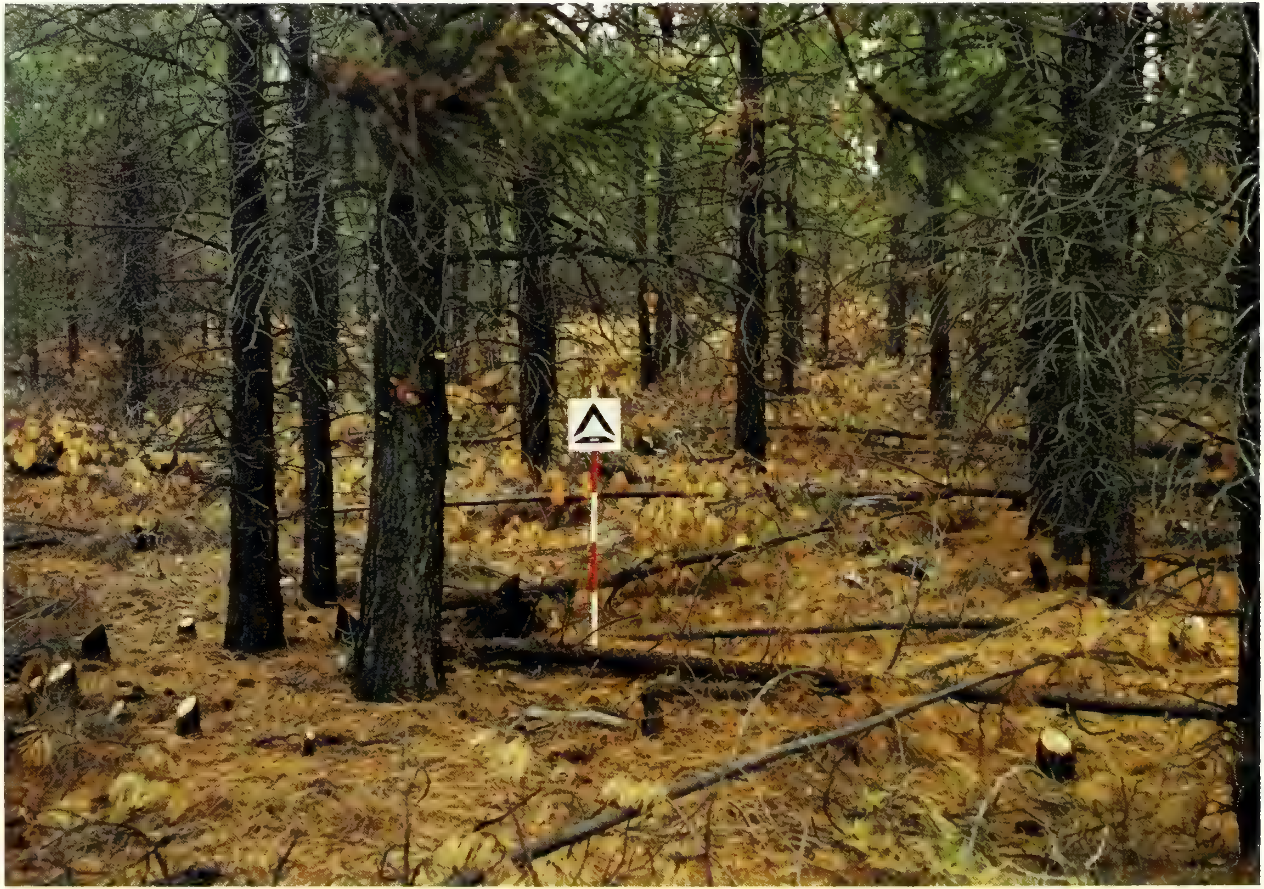
SIZE CLASS 1

PRECOMMERCIAL THINNING

A SERIES OF 6 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-PP-1-TH

DATA SHEET

Residue descriptive code 1-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.4	205
1.1-3.0	2.3	152
3.1-9.0	1.9	149
9.1-20.0	0	0
20.1+	0	0
Total	7.6	506

OTHER MEASUREMENTS

Average residue depth (feet) 0.5
Ground area covered by residue 1/4-inch diameter and larger (percent) 68
Average duff and litter depth (inches) 1.1
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 100
______ (percent) ____
______ (percent) ____
Rotted residue 3.1-inch diameter and larger (percent) ____

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) ____
Net volume cruised(M fbm/acre) ____
Average stems/acre cut ____
Average d.b.h. of stems cut (inches) ____
Stand age (years) ____
Cutting prescription ____
Yarding method ____
Slash treatment ____
Period since cut or treatment (months) ____

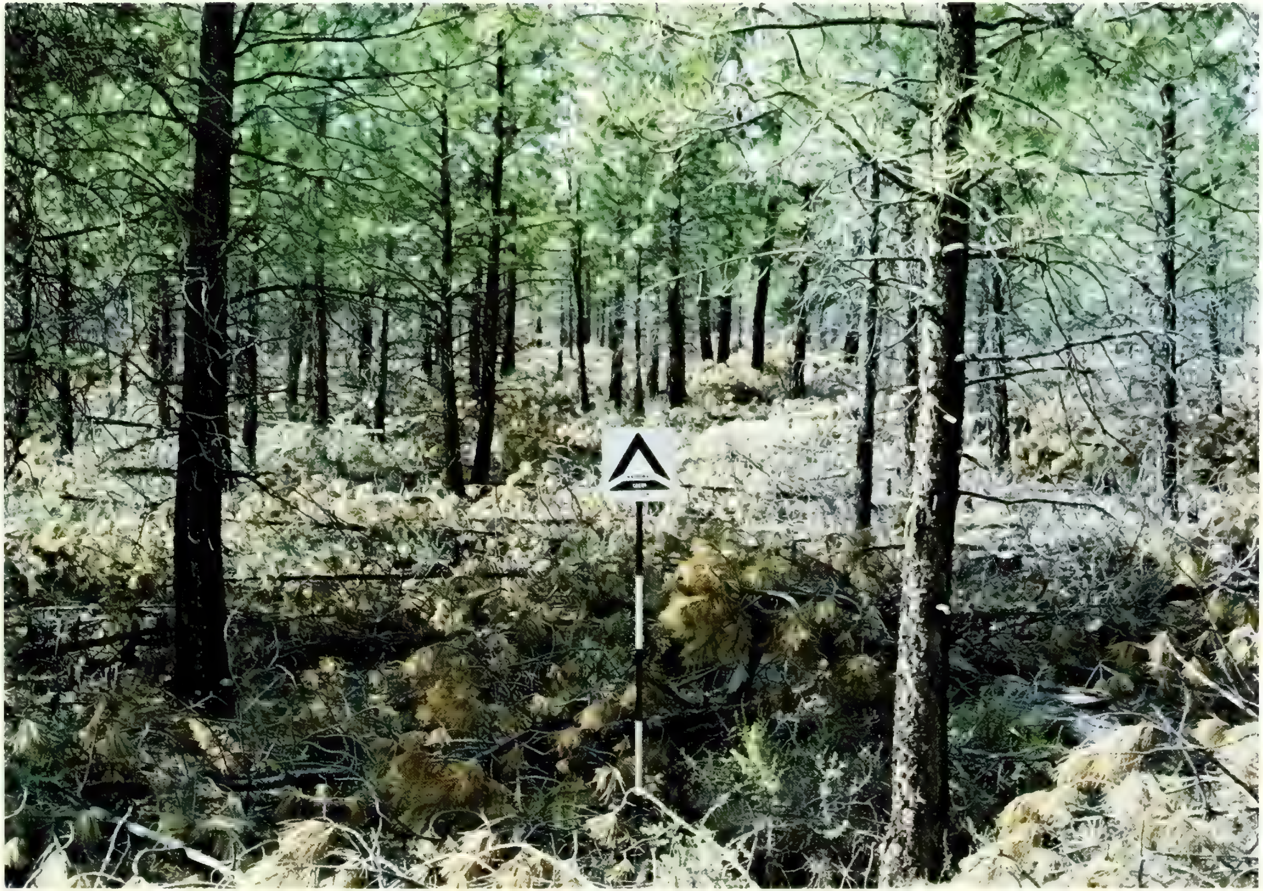
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 3,700
Stems remaining/acre 151
Basal area/acre before 336
Basal area/acre after 30
Average d.b.h. before (inches) 4
Average d.b.h. after (inches) 6
Thinning method Chainsaw
Slash treatment None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification EM

REMARKS



2-PP-1-TH

DATA SHEET

Residue descriptive code 2-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	2.7	0	164	0
1.1-3.0	5.5	0	358	0
3.1-9.0	2.3	[1]0.7	184	[1]71
9.1-20.0	0	[1]9.8	0	[1]1,044
20.1+	0	0	0	0
Total	10.5	[1]10.5	706	[1]1,115

OTHER MEASUREMENTS

Average residue depth	(feet)	0.7
Ground area covered by residue 1/4-inch diameter and larger	(percent)	79
Average duff and litter depth	(inches)	1.1
Sound residue 3.1-inch diameter and larger ponderosa pine	(percent)	39
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	61

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) ______
Net volume cruised(M fbm/acre) ______
Average stems/acre cut ______
Average d.b.h. of stems cut (inches) ______
Stand age (years) ______
Cutting prescription ______
Yarding method ______
Slash treatment ______
Period since cut or treatment (months) ______

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	2,825
Stems remaining/acre	175
Basal area/acre before	262
Basal area/acre after	34
Average d.b.h. before (inches)	4
Average d.b.h. after (inches)	6
Thinning method	Chainsaw
Slash treatment	None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Residue loadings footnoted were present prior to thinning.

One-half of tonnage in old-growth cull.

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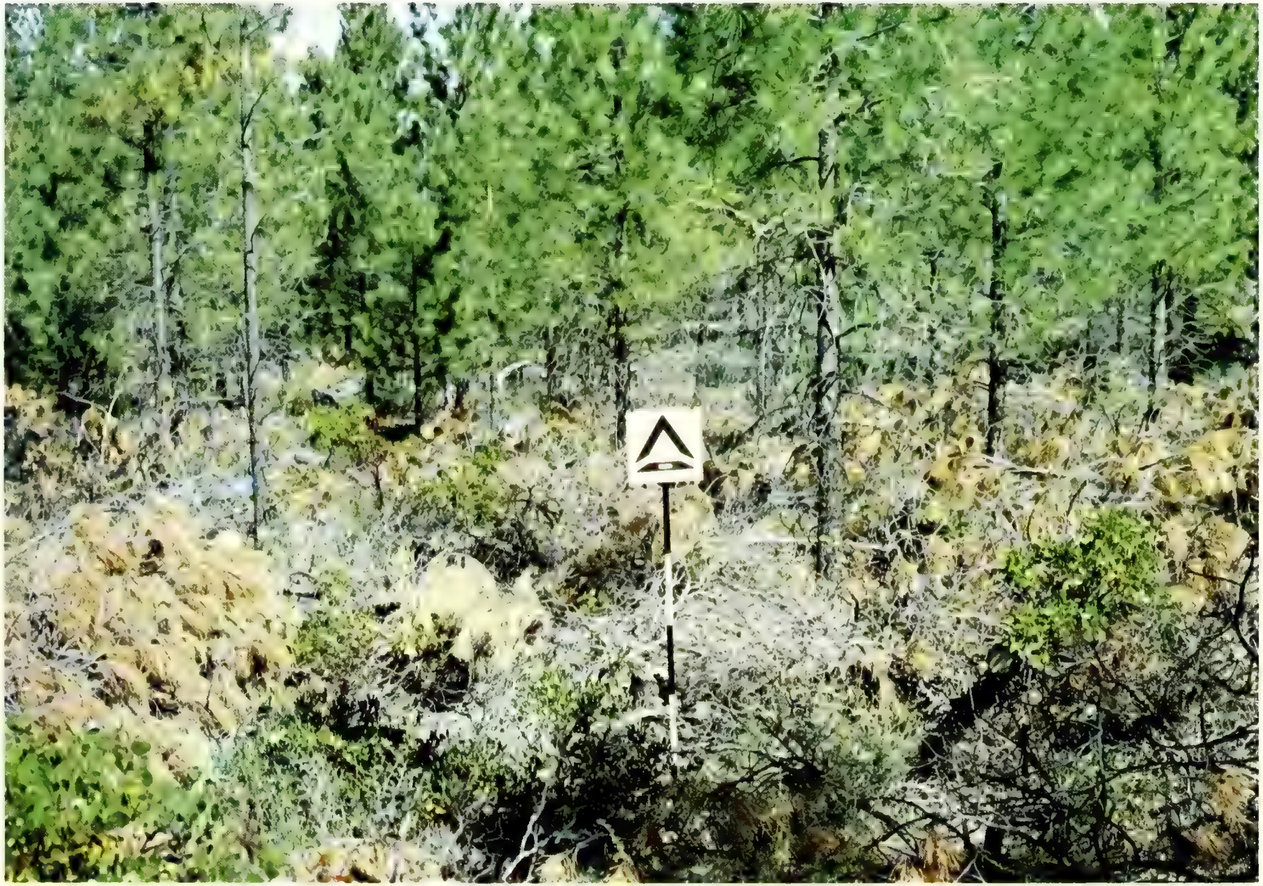
[1] See remarks.



3-PP-1-TH

DATA SHEET

Residue descriptive code 3-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	3.5	0	214	0
1.1-3.0	3.2	0	210	0
3.1-9.0	5.4	[1]0.6	431	[1]51
9.1-20.0	0	0	0	0
20.1+	0	0	0	0
Total	12.1	[1]0.6	855	[1]51

OTHER MEASUREMENTS

Average residue depth (feet) 1.2
Ground area covered by residue 1/4-inch diameter and larger (percent) 87
Average duff and litter depth (inches) 1.3
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 98
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 2

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)
Net volume cruised(M fbm/acre)
Average stems/acre cut
Average d.b.h. of stems cut (inches)
Stand age (years)
Cutting prescription
Yarding method
Slash treatment
Period since cut or treatment (months)

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 4,825
Stems remaining/acre 175
Basal area/acre before 436
Basal area/acre after 34
Average d.b.h. before (inches) 4
Average d.b.h. after (inches) 6
Thinning method Chainsaw
Slash treatment None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

Residue loadings footnoted were present prior to thinning.

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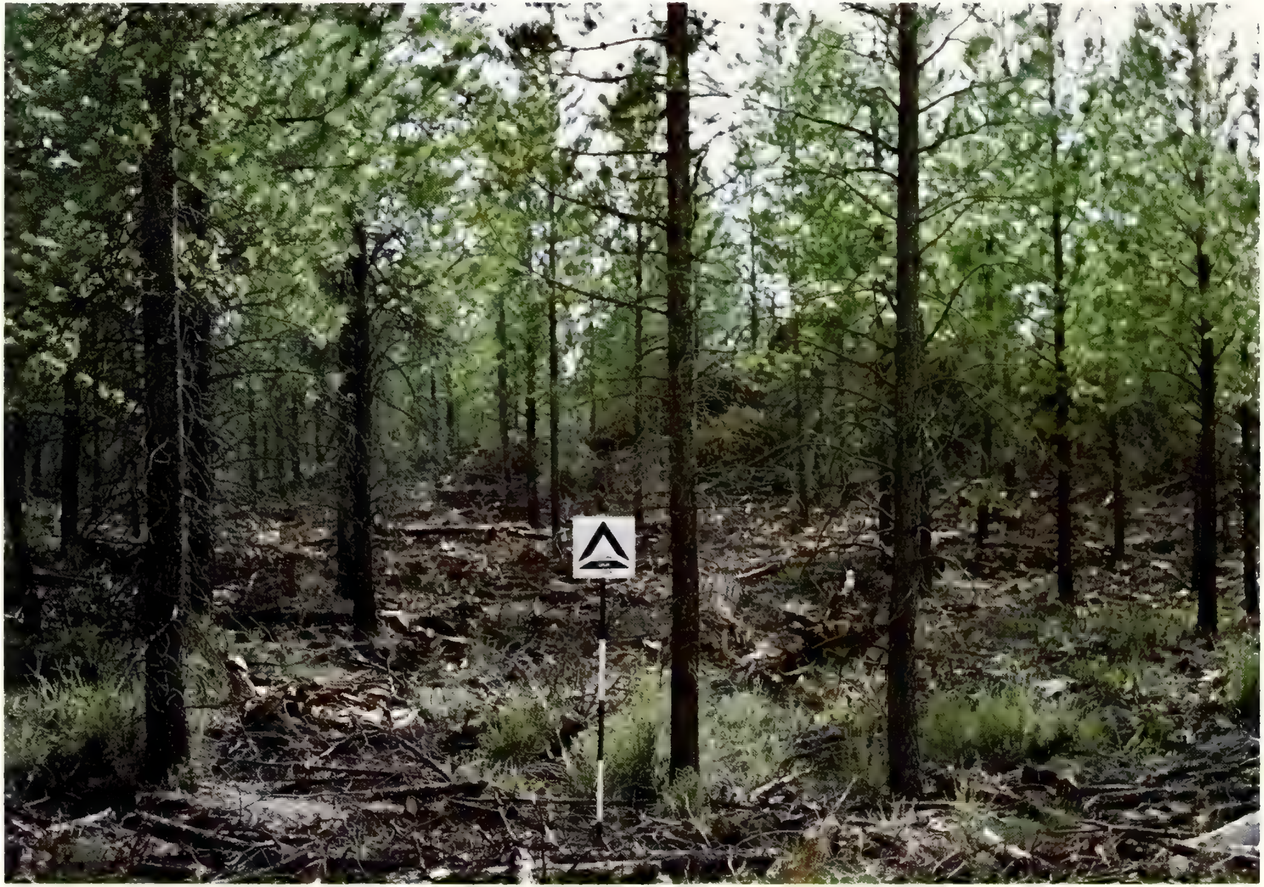
[1] See remarks.



4-PP-1-TH

DATA SHEET

Residue descriptive code 4-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	2.1	0	142	0
1.1-3.0	4.7	0	373	0
3.1-9.0	5.3	[1]0.5	423	[1]55
9.1-20.0	0	[1]2.0	0	[1]161
20.1+	0	0	0	0
Total	12.1	2.5	938	[1]216

OTHER MEASUREMENTS

Average residue depth (feet) 0.3

Ground area covered by residue 1/4-inch diameter and larger (percent) 79

Average duff and litter depth (inches) 1.4

Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 83

lodgepole pine (percent) 12

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 5

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)

Net volume cruised(M fbm/acre)

Average stems/acre cut

Average d.b.h. of stems cut (inches)

Stand age (years)

Cutting prescription

Yarding method

Slash treatment

Period since cut or treatment (months)

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 4,825

Stems remaining/acre 175

Basal area/acre before 436

Basal area/acre after 34

Average d.b.h. before (inches) 4

Average d.b.h. after (inches) 6

Thinning method Chainsaw

Slash treatment Crushed by Tomahawk

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MM

REMARKS

Residue loadings footnoted were present prior to thinning.

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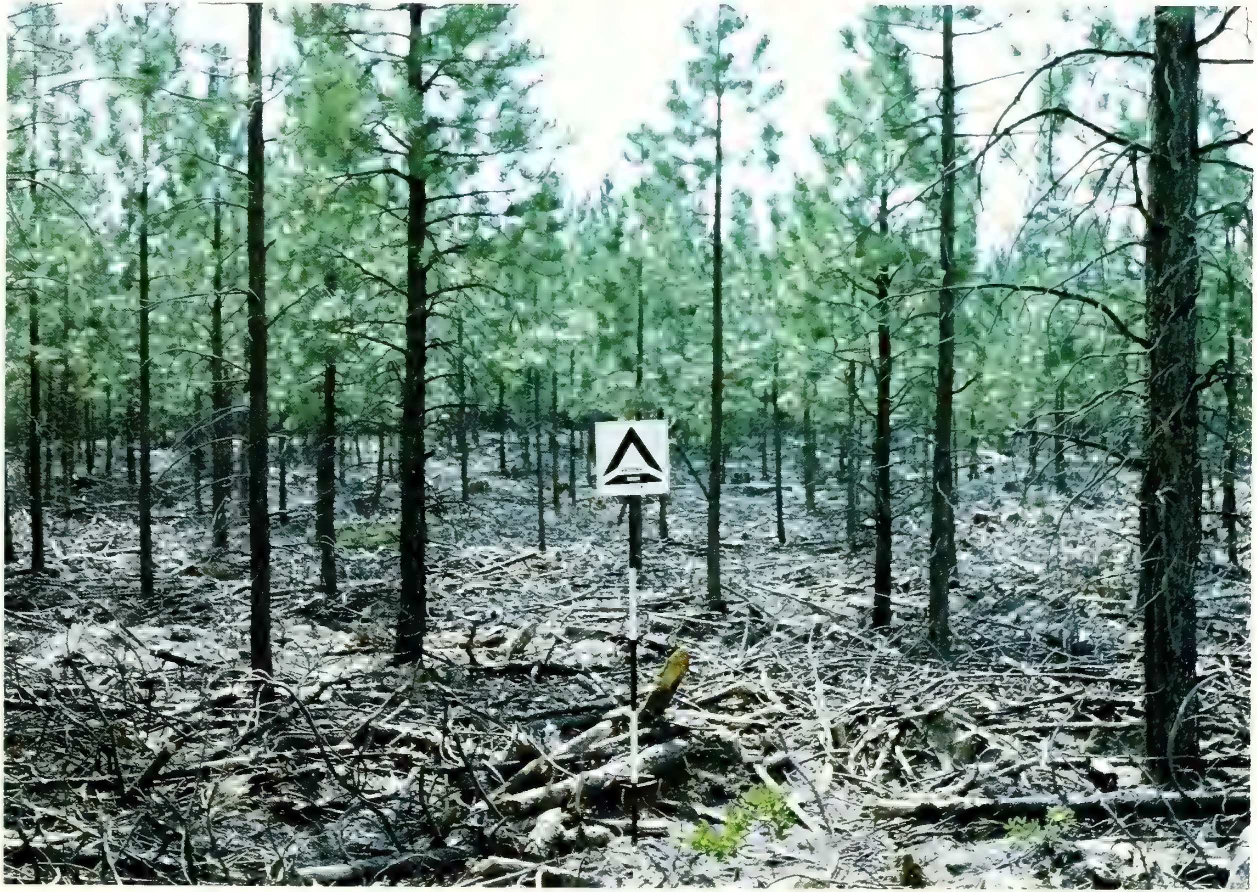
[1] See remarks.



5-PP-1-TH

DATA SHEET Residue descriptive code 5-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	5.2	0	317	0
1.1-3.0	13.0	0	850	0
3.1-9.0	3.9	[1]0.3	309	[1]28
9.1-20.0	0	0	0	0
20.1+	0	0	0	0
Total	22.1	[1]0.3	1,476	[1]28

OTHER MEASUREMENTS

Average residue depth (feet) 0.8
Ground area covered by residue 1/4-inch diameter and larger (percent) 89
Average duff and litter depth (inches) 0.7
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 98
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 2

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)
Net volume cruised(M fbm/acre)
Average stems/acre cut
Average d.b.h. of stems cut (inches)
Stand age (years)
Cutting prescription
Yarding method
Slash treatment
Period since cut or treatment (months)

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre 11,850
Stems remaining/acre 150
Basal area/acre before 589
Basal area/acre after 30
Average d.b.h. before (inches) 3
Average d.b.h. after (inches) 6
Thinning method Chainsaw
Slash treatment Crushed by Tomahawk

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS

Residue loadings footnoted were present prior to thinning.

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[1] See remarks.

6-PP-1-TH

DATA SHEET

Residue descriptive code 6-PP-1-TH

LOADING

Size class (inches)	Weight (tons/acre)		Volume (ft^3/acre)	
0.25-1.0	5.5	0	330	0
1.1-3.0	6.7	0	439	0
3.1-9.0	12.8	0	1,029	0
9.1-20.0	0	[1]0.2	0	[1]22
20.1+	3.5	0	283	0
Total	28.5	[1]0.2	2,081	[1]22

OTHER MEASUREMENTS

Average residue depth	(feet)	1.8
Ground area covered by residue 1/4-inch diameter and larger	(percent)	85
Average duff and litter depth	(inches)	1.9
Sound residue 3.1-inch diameter and larger ponderosa pine	(percent)	99
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	1

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)	
Net volume cruised(M fbm/acre)	
Average stems/acre cut	
Average d.b.h. of stems cut (inches)	
Stand age (years)	
Cutting prescription	
Yarding method	
Slash treatment	
Period since cut or treatment (months)	

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	4,825
Stems remaining/acre	175
Basal area/acre before	436
Basal area/acre after	34
Average d.b.h. before (inches)	4
Average d.b.h. after (inches)	6
Thinning method	Chainsaw
Slash treatment	None

FUEL RATING

U.S. Forest Service Region 6 fuel type identification EE

REMARKS

Residue loadings footnoted were present prior to thinning.

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[1] See remarks.

PONDEROSA PINE AND ASSOCIATED SPECIES

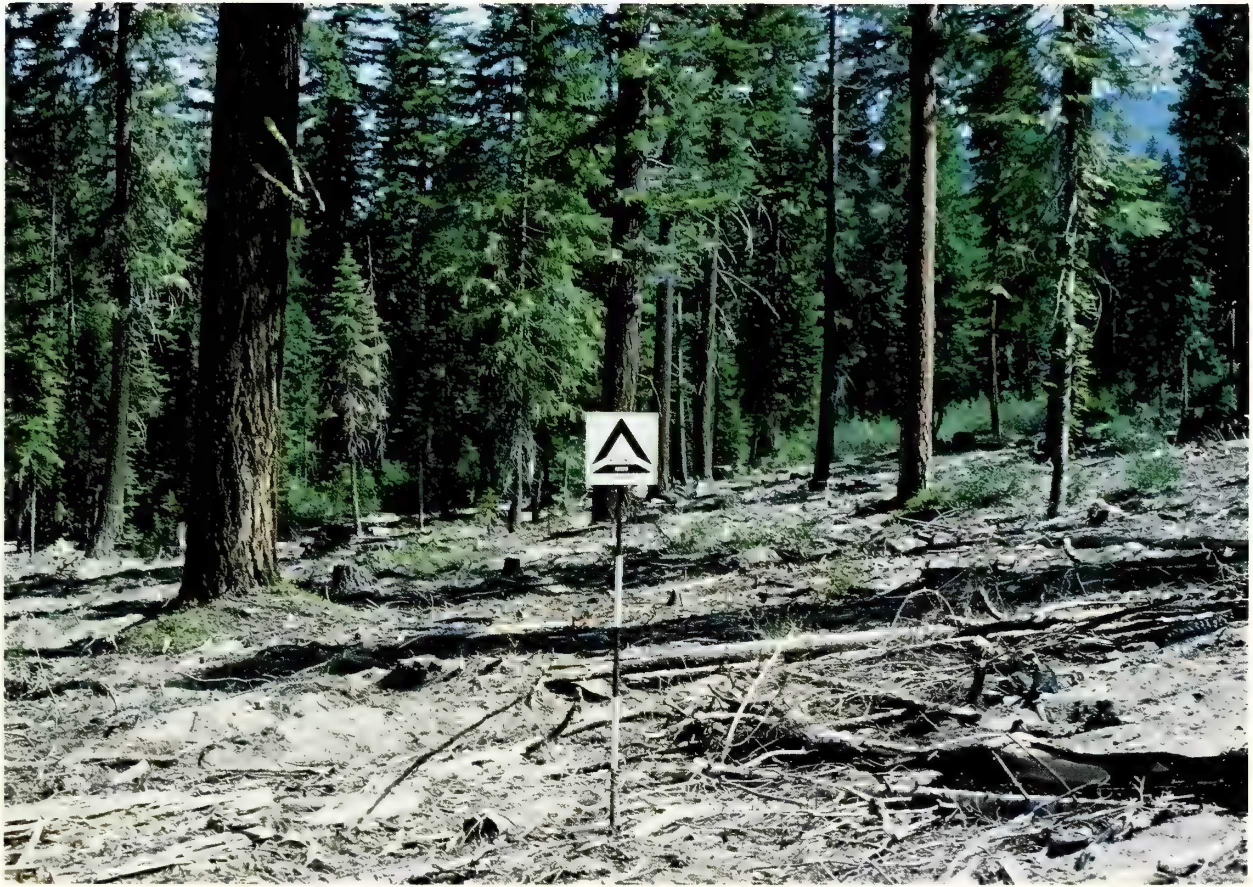
SIZE CLASS 4

PARTIAL CUT

A SERIES OF 8 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 1-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.4	94
1.1-3.0	3.7	298
3.1-9.0	3.5	274
9.1-20.0	0	0
20.1+	0	0
Total	8.6	666

OTHER MEASUREMENTS

Average residue depth (feet) 0.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 57

Average duff and litter depth (inches) 0.7

Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 45

ponderosa pine (percent) 11

other (percent) 17

Rotted residue 3.1-inch diameter and larger (percent) 27

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 28.0

Net volume cruised (M fbm/acre) 24.9

Average stems/acre cut 35

Average d.b.h. of stems cut (inches) 20

Stand age (years) 160+

Cutting prescription Shelterwood

Yarding method Tractor

Slash treatment Machine piled & burned

Period since cut or treatment (months) 36

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____

Stems remaining/acre ____

Basal area/acre before ____

Basal area/acre after ____

Average d.b.h. before (inches) ____

Average d.b.h. after (inches) ____

Thinning method ____

Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS

2-PP&ASSOC-4-PC

DATA SHEET Residue descriptive code 2-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.4	27
1.1-3.0	2.3	185
3.1-9.0	2.7	212
9.1-20.0	4.2	343
20.1+	8.4	671
Total	18.0	1,438

OTHER MEASUREMENTS

Average residue depth (feet) 0.2

Ground area covered by residue 1/4-inch diameter and larger (percent) 28

Average duff and litter depth (inches) 0.02

Sound residue 3.1-inch diameter and larger white fir (percent) 98

Douglas-fir (percent) 1

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 1

HARVEST INFORMATION

Gross volume cruised (M fbm/acre) 9.3

Net volume cruised (M fbm/acre) 5.9

Average stems/acre cut 11

Average d.b.h. of stems cut (inches) 26

Stand age (years) 250

Cutting prescription Tree selection

Yarding method High-lead

Slash treatment Broadcast burned

Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre

Stems remaining/acre

Basal area/acre before

Basal area/acre after

Average d.b.h. before (inches)

Average d.b.h. after (inches)

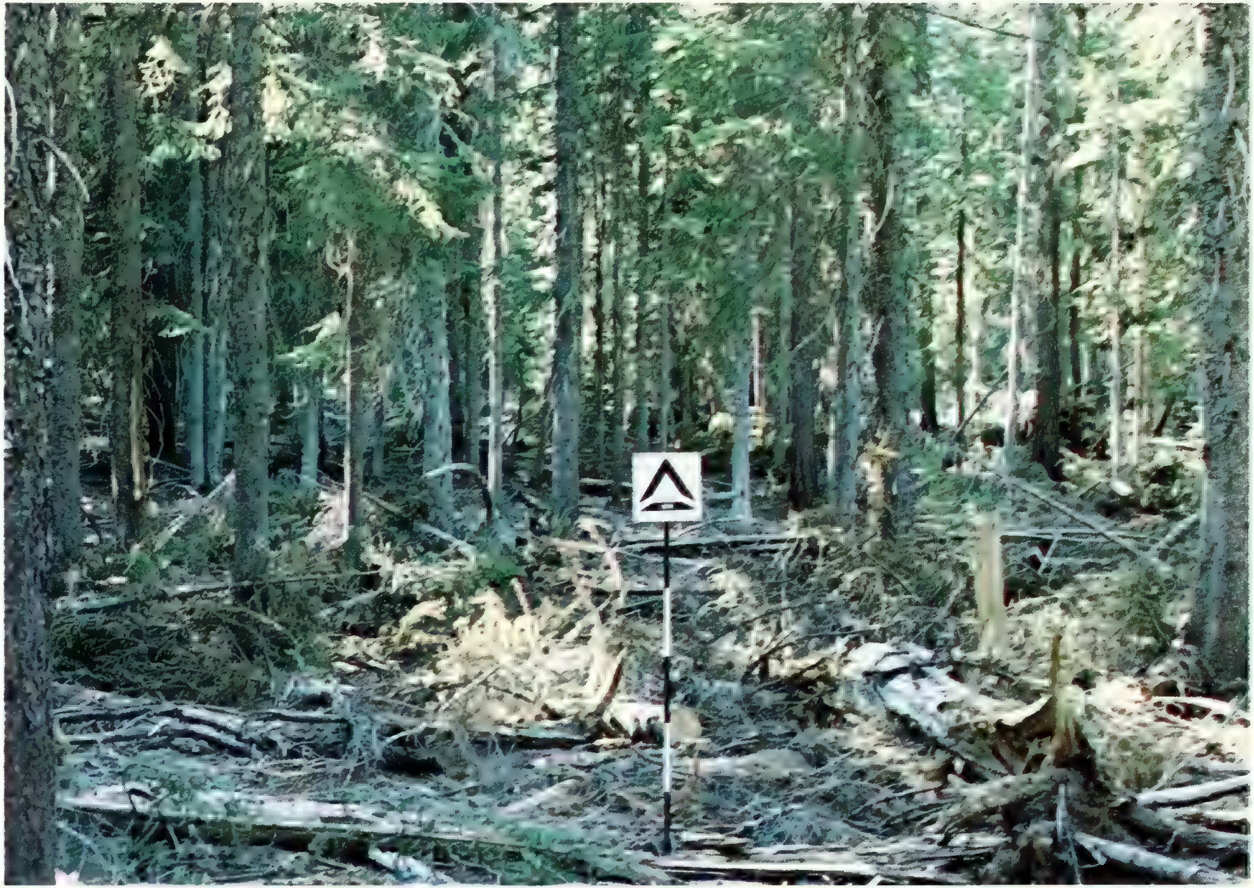
Thinning method

Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



3-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 3-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.2	213
1.1-3.0	4.8	386
3.1-9.0	12.3	1,020
9.1-20.0	5.4	443
20.1+	0	0
Total	25.7	2,062

OTHER MEASUREMENTS

Average residue depth	(feet)	0.6
Ground area covered by residue 1/4-inch diameter and larger	(percent)	85
Average duff and litter depth	(inches)	5.0
Sound residue 3.1-inch diameter and larger white fir	(percent)	89
subalpine fir	(percent)	3
other	(percent)	5
Rotted residue 3.1-inch diameter and larger	(percent)	3

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)	7.0
Net volume cruised(M fbm/acre)	4.6
Average stems/acre cut	23
Average d.b.h. of stems cut (inches)	17
Stand age (years)	200+
Cutting prescription	Tree selection
Yarding method	Tractor
Slash treatment	None
Period since cut or treatment (months)	<12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______

Stems remaining/acre ______

Basal area/acre before ______

Basal area/acre after ______

Average d.b.h. before (inches) ______

Average d.b.h. after (inches) ______

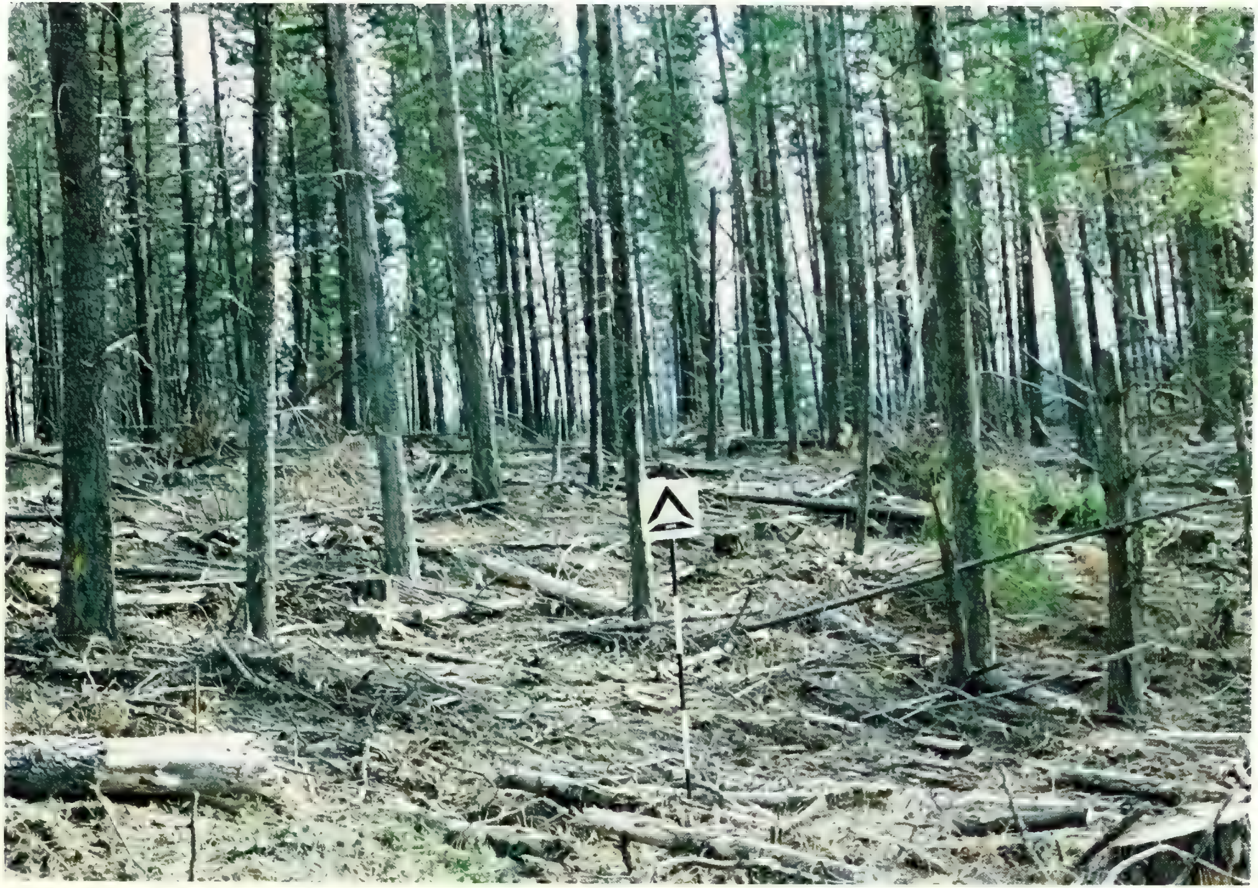
Thinning method ______

Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS



4-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 4-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.0	198
1.1-3.0	5.4	433
3.1-9.0	9.1	681
9.1-20.0	0	0
20.1+	11.7	781
Total	29.2	2,093

OTHER MEASUREMENTS

Average residue depth		(feet)	0.3
Ground area covered by residue 1/4-inch diameter and larger		(percent)	75
Average duff and litter depth		(inches)	2.0
Sound residue 3.1-inch diameter and larger	Douglas-fir	(percent)	78
	ponderosa pine	(percent)	14
	other	(percent)	1
Rotted residue 3.1-inch diameter and larger		(percent)	7

HARVEST INFORMATION

Gross volume cruised (M fbm/acre)	10.2
Net volume cruised (M fbm/acre)	10.0
Average stems/acre cut	110
Average d.b.h. of stems cut (inches)	14
Stand age (years)	80
Cutting prescription	Tree selection
Yarding method	Rubber-tired skidder
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	<12

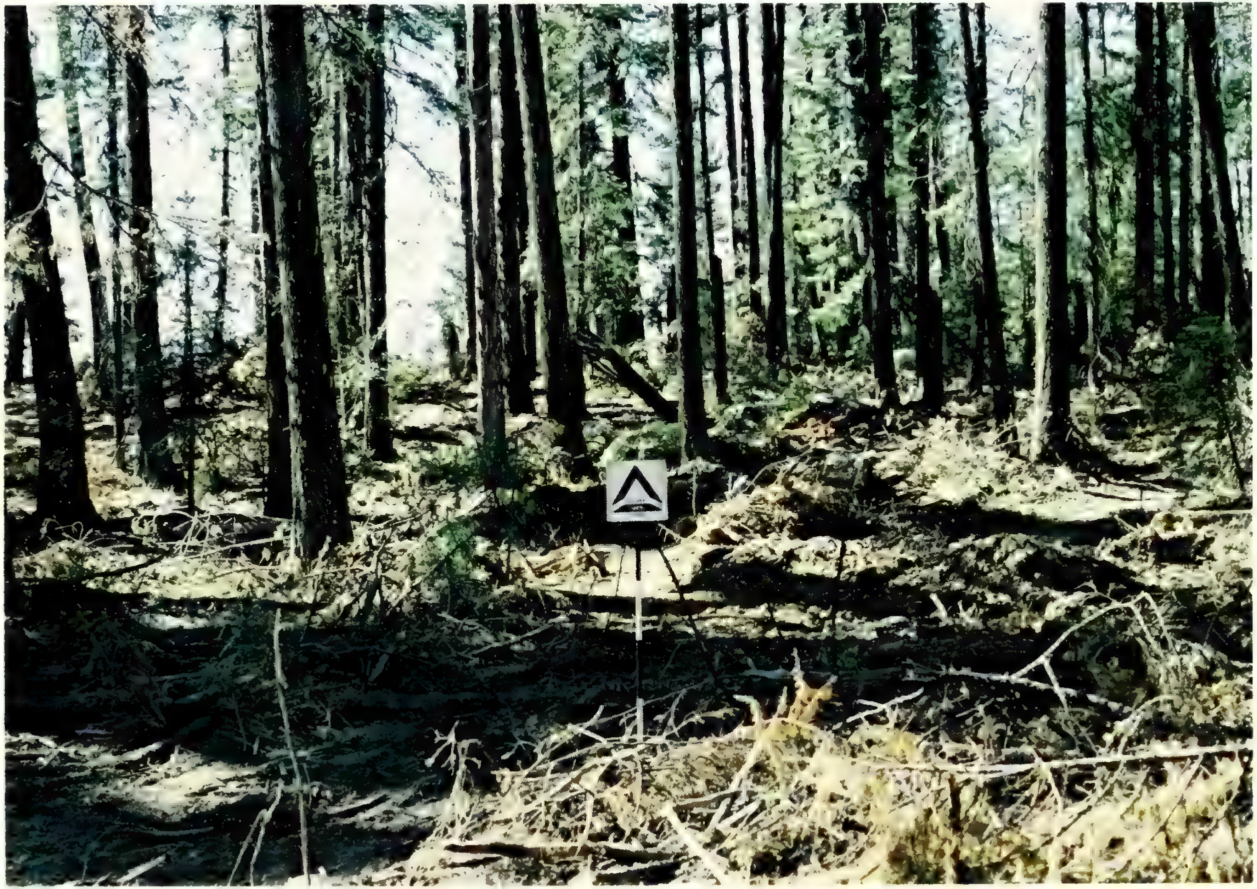
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification	MH

REMARKS



5-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 5-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.4	162
1.1-3.0	5.1	409
3.1-9.0	10.2	768
9.1-20.0	8.6	617
20.1+	3.0	200
Total	29.3	2,156

OTHER MEASUREMENTS

Average residue depth (feet) 0.4
Ground area covered by residue 1/4-inch diameter and larger (percent) 65
Average duff and litter depth (inches) 0.7
Sound residue 3.1-inch diameter and larger Douglas-fir (percent) 73
white fir (percent) 9
other (percent) 2
Rotted residue 3.1-inch diameter and larger (percent) 16

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 3.1
Net volume cruised(M fbm/acre) 2.0
Average stems/acre cut 17
Average d.b.h. of stems cut (inches) 15
Stand age (years) 200
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

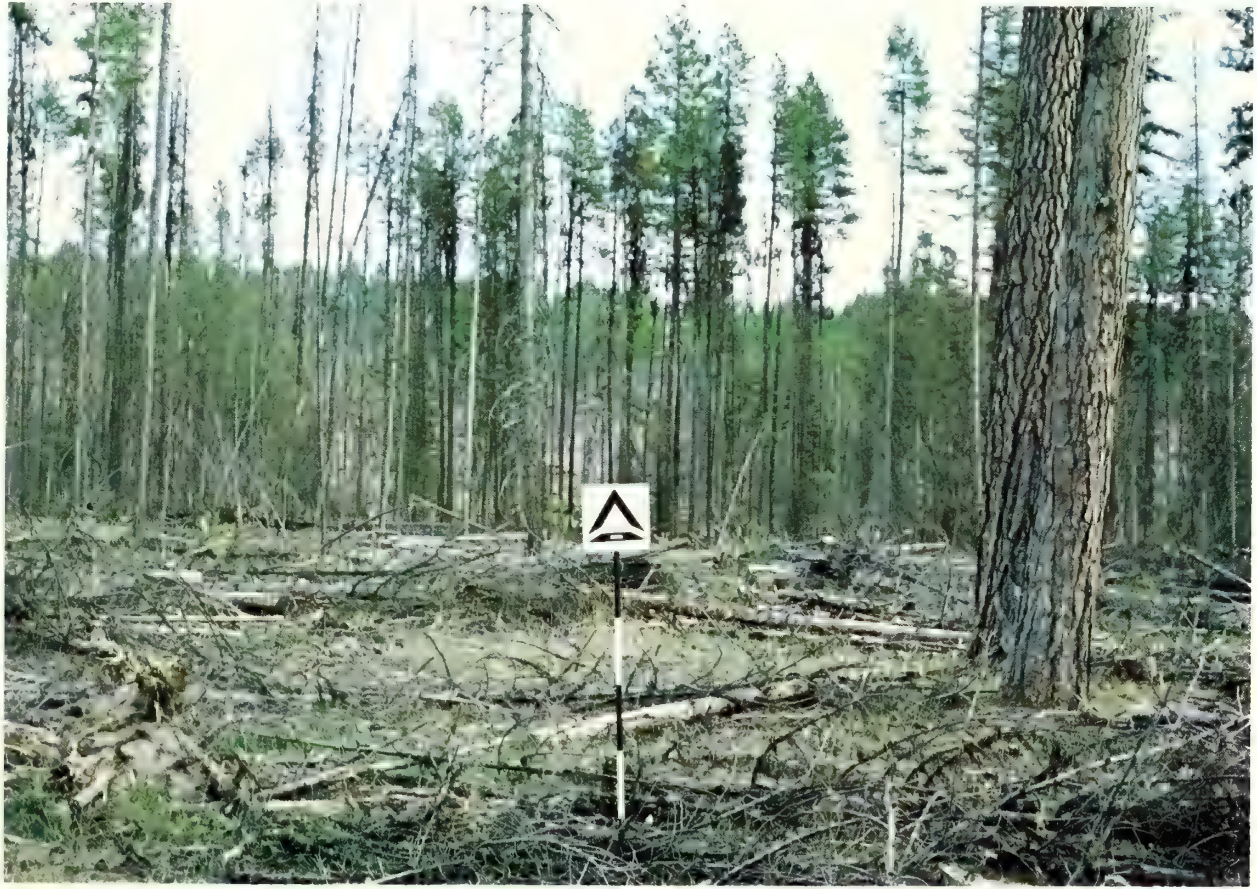
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



6-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 6-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	3.9	263
1.1-3.0	4.8	386
3.1-9.0	10.0	778
9.1-20.0	5.5	410
20.1+	6.9	458
Total	31.1	2,295

OTHER MEASUREMENTS

Average residue depth (feet) 0.7
Ground area covered by residue 1/4-inch diameter and larger (percent) 77
Average duff and litter depth (inches) 0.7
Sound residue 3.1-inch diameter and larger white fir (percent) 43
Douglas-fir (percent) 33
other (percent) 22
Rotted residue 3.1-inch diameter and larger (percent) 2

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 9.1
Net volume cruised(M fbm/acre) 8.0
Average stems/acre cut 41
Average d.b.h. of stems cut (inches) 15
Stand age (years) 170
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____
Stems remaining/acre ____
Basal area/acre before ____
Basal area/acre after ____
Average d.b.h. before (inches) ____
Average d.b.h. after (inches) ____
Thinning method ____
Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS

7-PP&ASSOC-4-PC

DATA SHEET   Residue descriptive code 7-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.6	176
1.1-3.0	5.9	474
3.1-9.0	27.1	1,874
9.1-20.0	2.3	196
20.1+	0	0
Total	37.9	2,720

OTHER MEASUREMENTS

Average residue depth		(feet)	0.6
Ground area covered by residue 1/4-inch diameter and larger		(percent)	89
Average duff and litter depth		(inches)	1.7
Sound residue 3.1-inch diameter and larger	western larch	(percent)	50
	white fir	(percent)	42
	other	(percent)	1
Rotted residue 3.1-inch diameter and larger		(percent)	7

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 3.1
Net volume cruised(M fbm/acre) 2.0
Average stems/acre cut 17
Average d.b.h. of stems cut (inches) 15
Stand age (years) 200
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

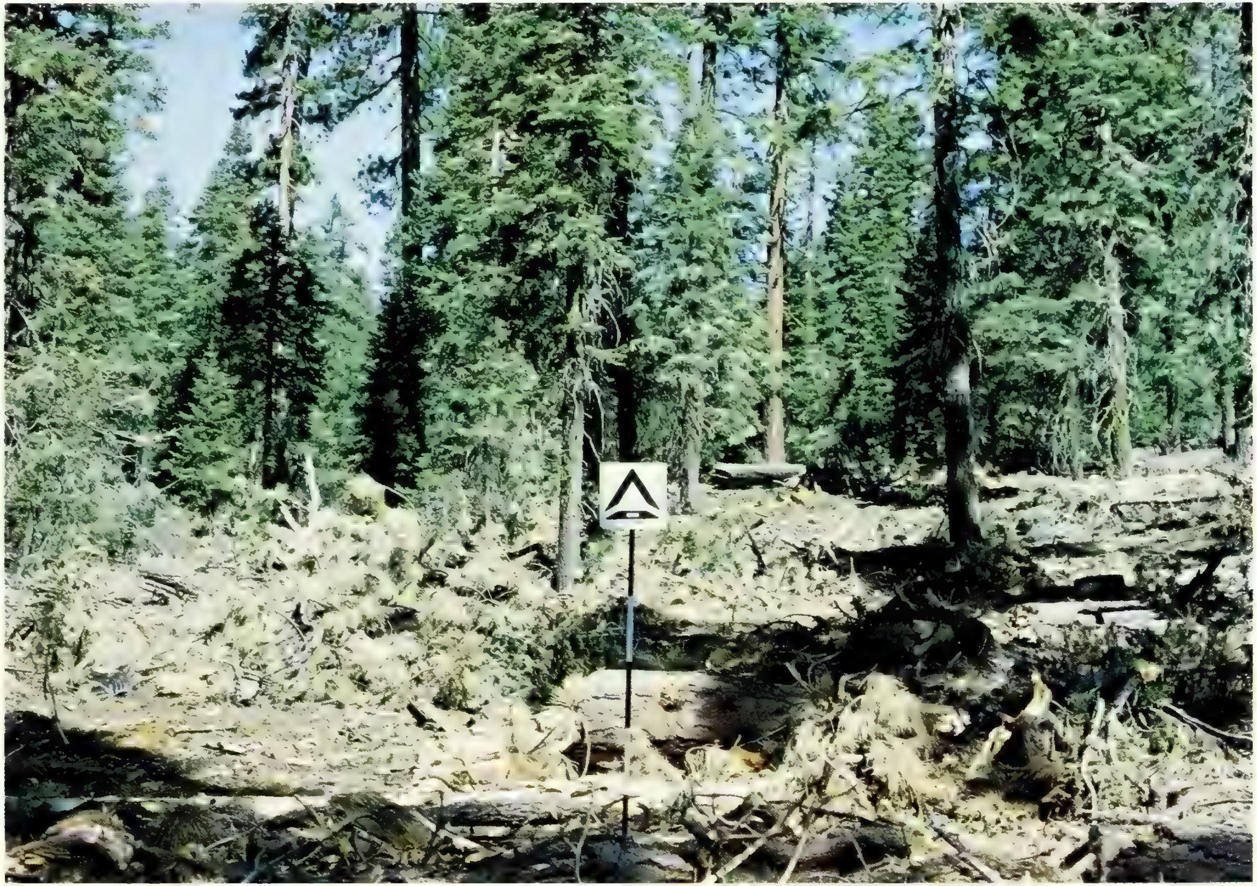
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ____
Stems remaining/acre ____
Basal area/acre before ____
Basal area/acre after ____
Average d.b.h. before (inches) ____
Average d.b.h. after (inches) ____
Thinning method ____
Slash treatment ____

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS



8-PP&ASSOC-4-PC

DATA SHEET

Residue descriptive code 8-PP&ASSOC-4-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.1	143
1.1-3.0	6.3	507
3.1-9.0	10.3	918
9.1-20.0	10.8	895
20.1+	11.6	930
Total	41.1	3,393

OTHER MEASUREMENTS

Average residue depth (feet) 0.4
Ground area covered by residue 1/4-inch diameter and larger (percent) 64
Average duff and litter depth (inches) 0.1
Sound residue 3.1-inch diameter and larger ponderosa pine (percent) 71
white fir (percent) 13
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 16

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 9.9
Net volume cruised(M fbm/acre) 9.1
Average stems/acre cut 9
Average d.b.h. of stems cut (inches) 27
Stand age (years) 300+
Cutting prescription Tree selection
Yarding method Tractor
Slash treatment None
Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

LODGEPOLE PINE

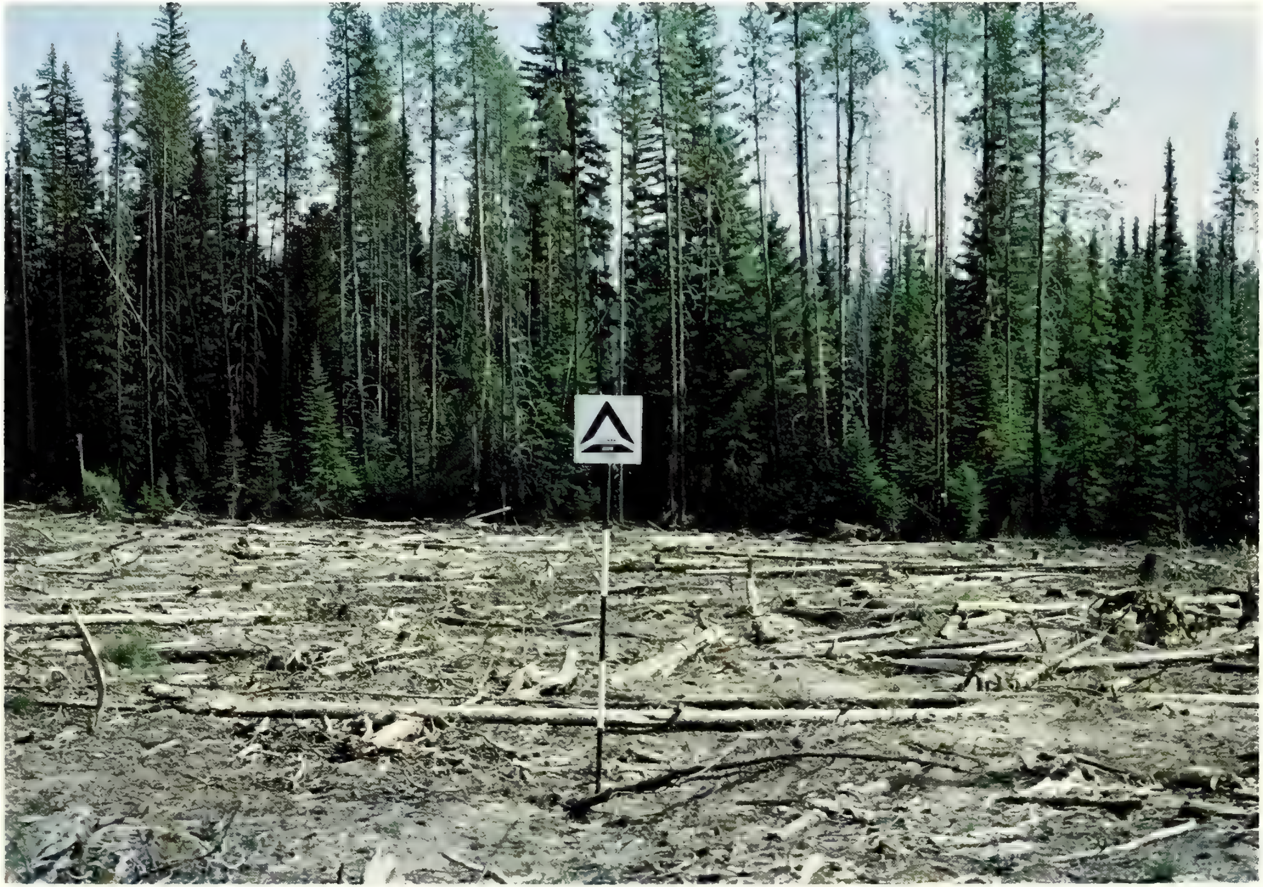
SIZE CLASS 3

CLEARCUT

1 LEVEL

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-LP-3-CC

DATA SHEET

Residue descriptive code 1-LP-3-CC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.3	89
1.1-3.0	5.5	442
3.1-9.0	8.1	636
9.1-20.0	1.1	88
20.1+	0	0
Total	16.0	1,255

OTHER MEASUREMENTS

Average residue depth	(feet)	0.2
Ground area covered by residue 1/4-inch diameter and larger	(percent)	60
Average duff and litter depth	(inches)	0.4
Sound residue 3.1-inch diameter and larger lodgepole pine	(percent)	100
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)	5.5
Net volume cruised(M fbm/acre)	4.6
Average stems/acre cut	51
Average d.b.h. of stems cut (inches)	31
Stand age (years)	150
Cutting prescription	Clearcut
Yarding method	Tractor
Slash treatment	Machine crushed
Period since cut or treatment (months)	12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification MH

REMARKS

LODGEPOLE PINE

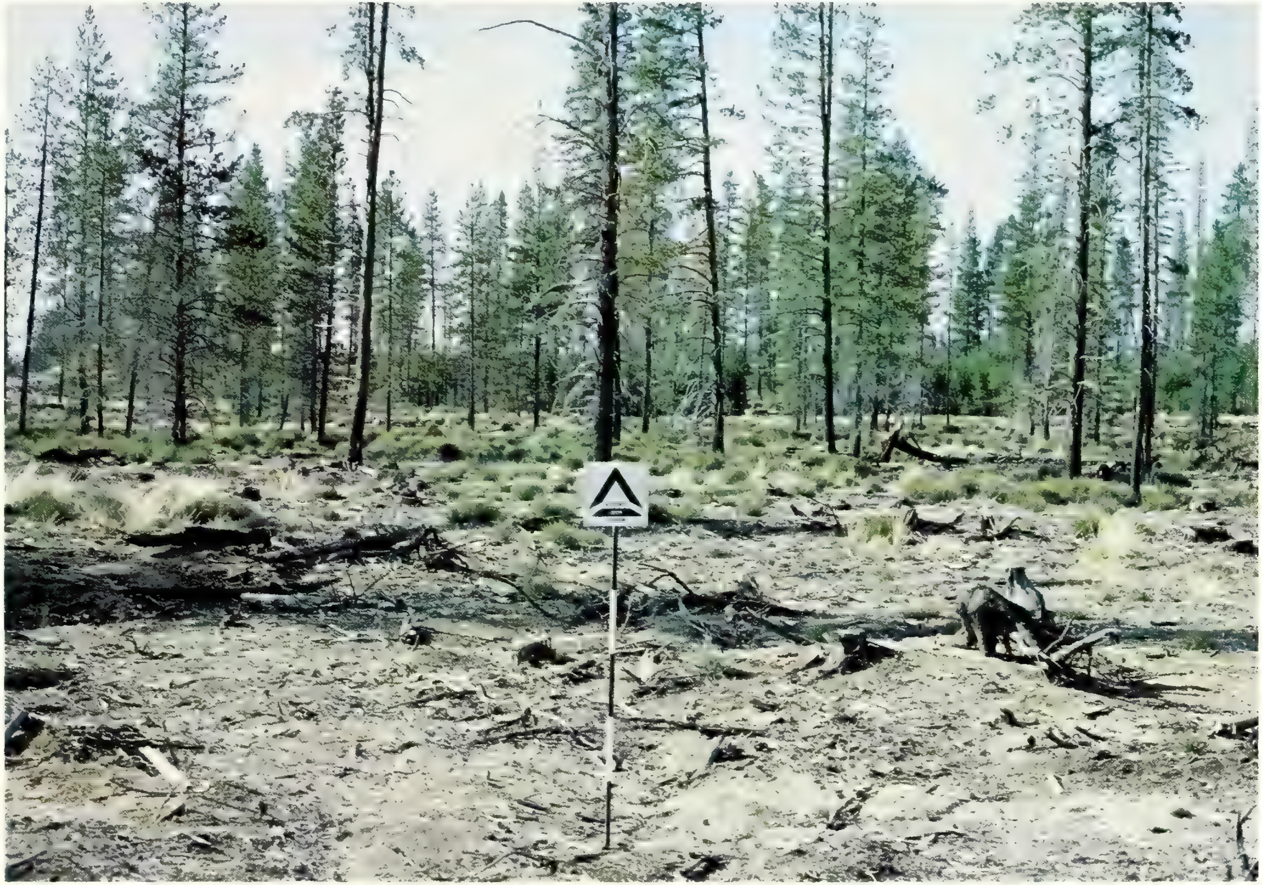
SIZE CLASS 3

PARTIAL CUT

A SERIES OF 5 LEVELS

Reminders to users:

1. The marker in these photos is 1 foot square, and the pole is painted in contrasting colors at 1-foot intervals to provide perspective.
2. Stumps are not included in residue quantities.
3. Rotted residue is that which would come apart or splinter when kicked.



1-LP-3-PC

DATA SHEET

Residue descriptive code 1-LP-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	0.8	56
1.1-3.0	1.7	135
3.1-9.0	0.9	70
9.1-20.0	0	0
20.1+	0	0
Total	3.4	261

OTHER MEASUREMENTS

Average residue depth	(feet)	0.04
Ground area covered by residue 1/4-inch diameter and larger	(percent)	31
Average duff and litter depth	(inches)	0.1
Sound residue 3.1-inch diameter and larger lodgepole pine	(percent)	100
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre)	7.6
Net volume cruised(M fbm/acre)	6.6
Average stems/acre cut	64
Average d.b.h. of stems cut (inches)	13
Stand age (years)	150
Cutting prescription	Shelterwood
Yarding method	Tractor
Slash treatment	Machine piled & burned
Period since cut or treatment (months)	24

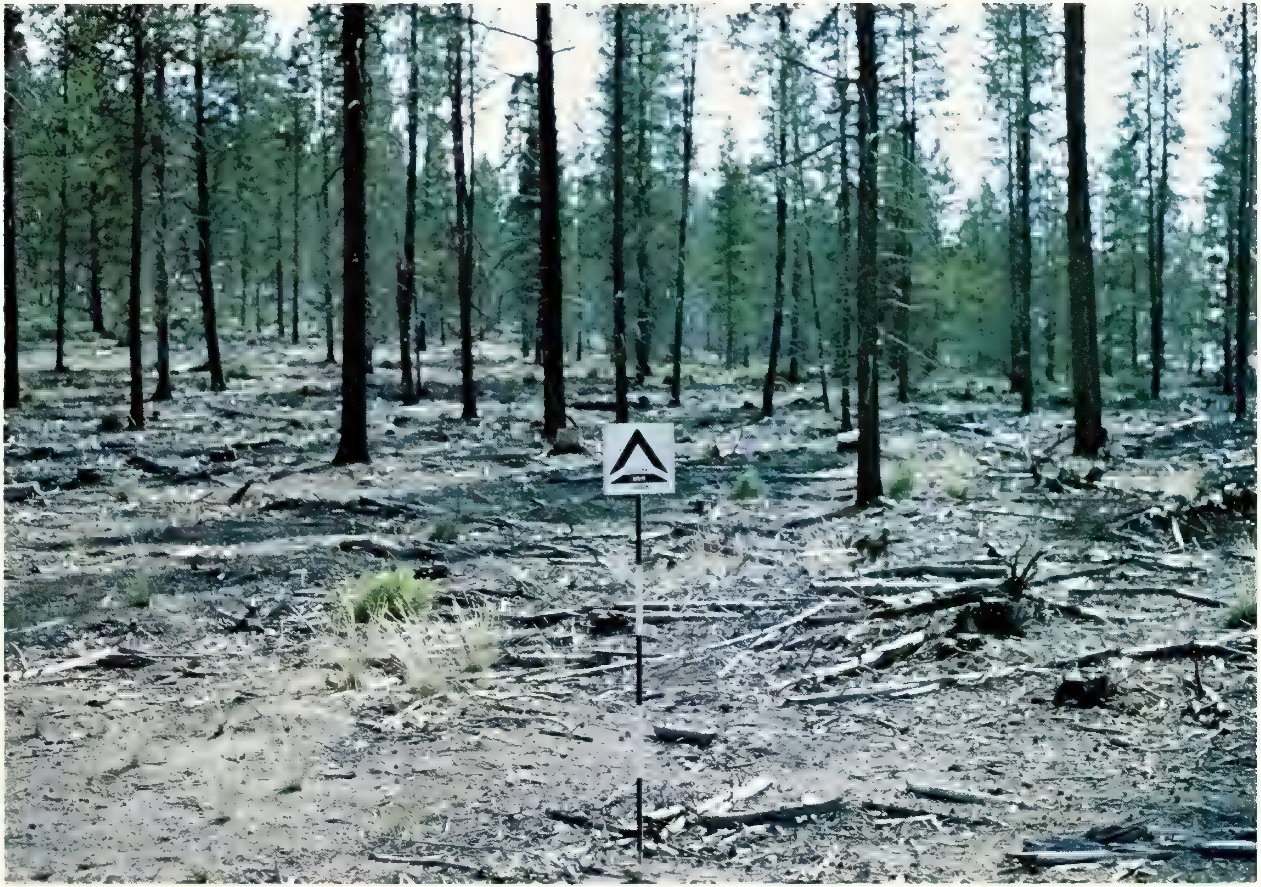
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre	
Stems remaining/acre	
Basal area/acre before	
Basal area/acre after	
Average d.b.h. before (inches)	
Average d.b.h. after (inches)	
Thinning method	
Slash treatment	

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LL

REMARKS



2-LP-3-PC

DATA SHEET

Residue descriptive code 2-LP-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.9	127
1.1-3.0	5.1	407
3.1-9.0	3.4	263
9.1-20.0	4.1	319
20.1+	0	0
Total	14.5	1,116

OTHER MEASUREMENTS

Average residue depth	(feet)	0.2
Ground area covered by residue 1/4-inch diameter and larger	(percent)	64
Average duff and litter depth	(inches)	0.4
Sound residue 3.1-inch diameter and larger lodgepole pine	(percent)	100
	(percent)	
	(percent)	
Rotted residue 3.1-inch diameter and larger	(percent)	0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 3.6
Net volume cruised(M fbm/acre) 3.1
Average stems/acre cut 25
Average d.b.h. of stems cut (inches) 13
Stand age (years) 150
Cutting prescription Shelterwood
Yarding method Tractor
Slash treatment Machine crushed
Period since cut or treatment (months) 36

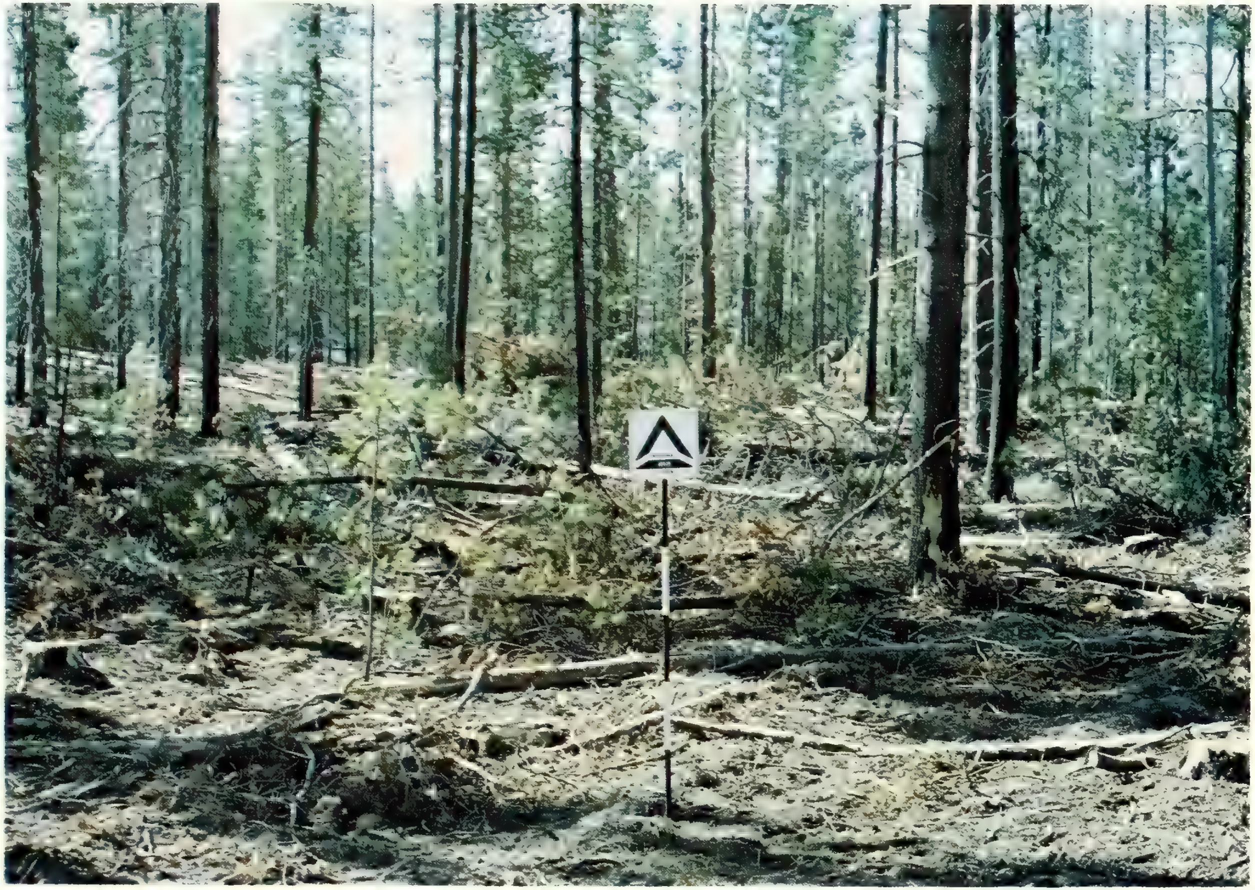
PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification LM

REMARKS



3-LP-3-PC

DATA SHEET

Residue descriptive code 3-LP-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	1.7	114
1.1-3.0	4.1	325
3.1-9.0	6.5	508
9.1-20.0	5.2	410
20.1+	0	0
Total	17.5	1,357

OTHER MEASUREMENTS

Average residue depth (feet) 0.3

Ground area covered by residue 1/4-inch diameter and larger (percent) 61

Average duff and litter depth (inches) 0.5

Sound residue 3.1-inch diameter and larger lodgepole pine (percent) 99

ponderosa pine (percent) 1

(percent)

Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 6.7

Net volume cruised(M fbm/acre) 6.2

Average stems/acre cut 18

Average d.b.h. of stems cut (inches) 10

Stand age (years) 80+

Cutting prescription Overstory removal

Yarding method Rubber-tired skidder

Slash treatment None

Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre

Stems remaining/acre

Basal area/acre before

Basal area/acre after

Average d.b.h. before (inches)

Average d.b.h. after (inches)

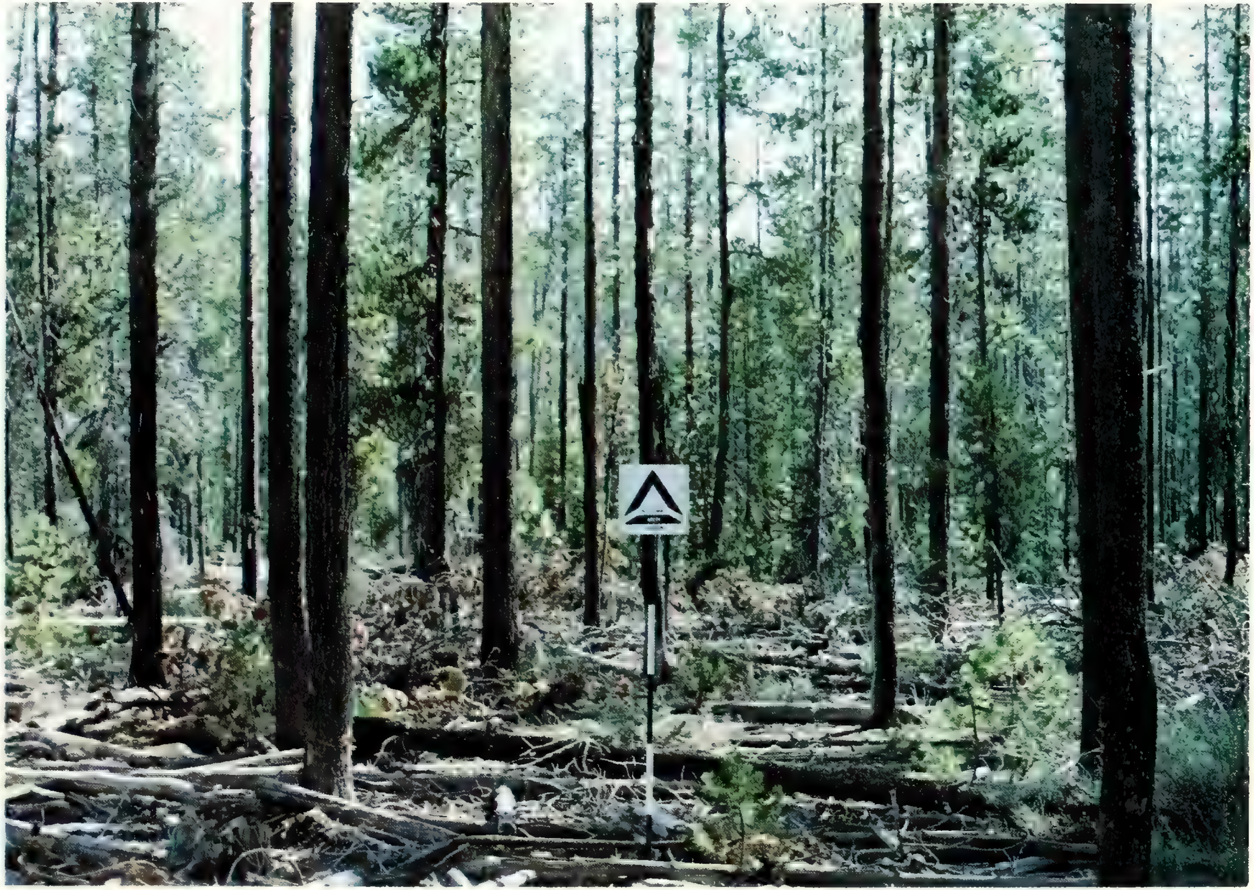
Thinning method

Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HM

REMARKS



4-LP-3-PC

DATA SHEET

Residue descriptive code 4-LP-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.5	169
1.1-3.0	6.6	526
3.1-9.0	15.8	1,231
9.1-20.0	1.2	91
20.1+	0	0
Total	26.1	2,017

OTHER MEASUREMENTS

Average residue depth (feet) 0.5
Ground area covered by residue 1/4-inch diameter and larger (percent) 79
Average duff and litter depth (inches) 0.7
Sound residue 3.1-inch diameter and larger lodgepole pine (percent) 100
(percent)
(percent)
Rotted residue 3.1-inch diameter and larger (percent) 0

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 3.2
Net volume cruised(M fbm/acre 2.0
Average stems/acre cut 23
Average d.b.h. of stems cut (inches) 12
Stand age (years) 110
Cutting prescription Tree selection
Yarding method Rubber-tired skidder
Slash treatment None
Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre
Stems remaining/acre
Basal area/acre before
Basal area/acre after
Average d.b.h. before (inches)
Average d.b.h. after (inches)
Thinning method
Slash treatment

FUEL RATING

U.S. Forest Service Region 6 fuel type identification HH

REMARKS

5-LP-3-PC

DATA SHEET

Residue descriptive code 5-LP-3-PC

LOADING

Size class (inches)	Weight (tons/acre)	Volume (ft^3/acre)
0.25-1.0	2.4	162
1.1-3.0	6.9	555
3.1-9.0	20.7	1,628
9.1-20.0	5.8	525
20.1+	0	0
Total	35.8	2,870

OTHER MEASUREMENTS

Average residue depth (feet) 0.5
Ground area covered by residue 1/4-inch diameter and larger (percent) 85
Average duff and litter depth (inches) 0.9
Sound residue 3.1-inch diameter and larger lodgepole pine (percent) 86
______ (percent) ______
______ (percent) ______
Rotted residue 3.1-inch diameter and larger (percent) 14

HARVEST INFORMATION

Gross volume cruised(M fbm/acre) 3.6
Net volume cruised(M fbm/acre) 3.2
Average stems/acre cut 51
Average d.b.h. of stems cut (inches) 13
Stand age (years) 110
Cutting prescription Tree selection[1/]
Yarding method Rubber-tired skidder
Slash treatment None
Period since cut or treatment (months) <12

PRECOMMERCIAL THINNING INFORMATION

Stems cut/acre ______
Stems remaining/acre ______
Basal area/acre before ______
Basal area/acre after ______
Average d.b.h. before (inches) ______
Average d.b.h. after (inches) ______
Thinning method ______
Slash treatment ______

FUEL RATING

U.S. Forest Service Region 6 fuel type identification FE

REMARKS

All trees over 10 inches in diameter selected for cutting.

[1/] See remarks.

GPO 697-589

The mission of the **PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION** is to provide the knowledge, technology, and alternatives for present and future protection, management, and use of forest, range, and related environments.

Within this overall mission, the Station conducts and stimulates research to facilitate and to accelerate progress toward the following goals:

1. Providing safe and efficient technology for inventory, protection, and use of resources.
2. Developing and evaluating alternative methods and levels of resource management.
3. Achieving optimum sustained resource productivity consistent with maintaining a high quality forest environment.

The area of research encompasses Oregon, Washington, Alaska, and, in some cases, California, Hawaii, the Western States, and the Nation. Results of the research are made available promptly. Project headquarters are at:

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Experiment Station
P.O. Box 3141
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GOAL PROGRAMING FOR LAND USE PLANNING

Enoch F. Bell

PACIFIC NORTHWEST FOREST AND RANGE EXPERIMENT STATION
U.S. DEPARTMENT OF AGRICULTURE FOREST SERVICE
PORTLAND, OREGON

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ABSTRACT

A simple transformation of the linear programing model used in land use planning to a goal programing model allows the multiple goals implied by multiple use management to be explicitly recognized. This report outlines the procedure for accomplishing the transformation and discusses problems with use of goal programing. Of particular concern are the expert opinions often required to set up the programing matrix, the need for quantitative goals, the choice of relative weights for the goals, and the lack of explicit trade-offs. The relationships of goal programing to linear programing and the "satisficing" decision model are also discussed. Goal programming is not a panacea for poor planning and must be used with full recognition of its problems.

KEYWORDS: Management planning (forest), land use, National Forest development policy.

Metric conversions

1,000 acres = 404.69 hectares

1,000 cubic feet = 28.3 cubic meters

1 ton = 0.9072 tonne

1 pound = 0.4536 kilogram

INTRODUCTION

The purpose of land use planning on National Forests is "to promote the accomplishment of servicewide objectives and targets" subject to the land's potential and the public's desires (USDA Forest Service 1973a). To assure that this objective is met, the Forest Service has established guidelines for land use planning (USDA Forest Service 1973a). These guidelines are broad enough for considerable latitude in choice of planning tool. The National Forests in the Pacific Northwest Region have tried a number of comprehensive planning tools ranging from the computer complexities of Resource Capability System (USDA Forest Service 1973b) to the overlays proposed by McHarg (1969). However, the most common tool used is a formulation of linear programing (L-P) in which various average annual outputs are maximized or constrained according to alternative management schemes applied to specified acreages. In situations where a goal-oriented planning framework exists, modification of the L-P model to make it a goal programing model can provide increased flexibility in the land use planning process.

The purpose of this paper is to present a representative formulation of the L-P application and show how it may be modified for goal programing. In addition, various considerations and restrictions will be discussed so that land use planners and others interested in these techniques can become aware of the assumptions and problems involved in their application.

LINEAR PROGRAMING IN UNIT PLANNING

In land use planning on National Forests, each Forest is divided into large areas called planning units. For each unit, goals are established and a resource inventory is made. Then the planning unit is divided into homogeneous blocks of land or analysis units. These analysis units are separated on the basis of soils, stand types, elevation, etc., according to similarity of response to particular management programs.

Next, major present and potential outputs are identified for each analysis unit, and alternative management activities are drawn up emphasizing each output respectively but recognizing other outputs that jointly occur. The potential average annual outputs per acre and inputs are quantified for each activity. Table 1, which was developed for a particular analysis unit under present levels of inputs, shows an example of information produced by this procedure. The rows represent the major outputs, and the columns show the per-acre outputs associated with the alternative management activities. For instance, if we wish to emphasize grazing on an acre of this unit, we can expect to annually produce 150 pounds of forage, 0.5 potential visitor-days of dispersed recreation, 0.8 acre-feet

Table 1--*Example of an individual analysis unit output matrix*

Output per acre	Management activity		
	Dispersed recreation	Grazing	Wilderness
Timber (M fbm)	0	0	0
Forage (lb)	100.0	150.0	100.0
Dispersed recreation (visitor days)	2.0	.5	.1
Water (acre-ft)	.8	.8	.8
Sediment (tons)	4.0	4.0	3.0
Wilderness (acres)	0	0	1.0

of water, 4.0 tons of sediment, and no wilderness.

The next step is to combine the results of the above procedure applied to each analysis unit into a matrix suitable for L-P such as is shown in figure 1. For this example, the three units to be analyzed are identified as 1A, 3A, and 6A. Unit 1A is similar to the unit shown in table 1. The column labels identify the primary output emphasis such as dispersed recreation, forage, and wilderness of the various management activities.

Next, the resource's productive potential is considered when desired output levels for the planning unit are established. These output goals are placed on the right-hand side of the matrix and set up as constraints below or above which the output is desired to be restricted. For example, in figure 1 the output of sediment has been restricted to less than or equal to 235,000 tons per year for the planning unit.

Finally, acreage and other special constraints must be added to the matrix. The acreage constraints require that the number of acres managed under the various management activities for a particular analysis unit be less than or equal to the number of acres in that unit. In figure 1, the acres managed in units 1A, 3A, and 6A must equal 10,000, 15,000, and 20,000, respectively.

Additional special constraints may be set up, depending on other objectives that might not have been expressed explicitly. For example, in figure 1, rows 7 and 8 restrict wilderness to between 2,000 and 4,000 acres. Row 12, on the other hand, is set up to require 300 acres of modified timber management buffer zone (column 11) for each acre of developed recreation (column 10). Other constraints can be included as desired.

With the standard linear programing format, any row (output) may be chosen as the objective function and minimized or maximized as desired. However, it should be noted that only one objective function can be specified at any one time with the other goals as constraints. For figure 1, the objective of maximizing timber production was chosen. After compilation of the matrix and specification of the objective function, the data are submitted to an appropriate computer program for solution.

The solution is expressed in number of acres in each analysis unit that will be allocated to the various management activities. For example, the solution (not shown) for the problem in figure 1 places 7,990 acres of unit 1A in the management activity which emphasizes dispersed recreation (column 1). In addition, the solution will also display total outputs of the planning unit. Alternative solutions are usually obtained by varying the objective function and the output levels.

At this point in the process we have quantitative estimates of acres assigned to each management activity and output levels for each alternative set of objectives and constraints. Although this is the end of the linear programing phase of the process, it is not the end of the total process. Still remaining is the assessment of the environmental, social, and economic effects of carrying out each alternative, informing the public of the alternatives and their consequences, and finally making a decision and implementing it. During this process, the linear programing matrix may be modified and rerun at any time to show the consequences of different constraints and assumptions for input into the decisionmaking process.

ASSUMPTIONS IN PROGRAMING FOR UNIT PLANNING

The planner must be aware of several problems with the overall procedure. In addition to the often recognized problems of poor data, insufficient analysis, and failure to consider enough alternatives, some assumptions inherent in the linear programing formulation must also be considered.

First is the assumption that each analysis unit is homogeneous. That is, for each unit, every acre is the same as the average acre used in the analysis. This is generally not true; but to the extent that care is taken to select homogeneous analysis units, this problem can be minimized. In some cases, divisions of present units may be necessary to provide a greater degree of homogeneity. Dividing into

Output	Analysis unit of land													Right-hand side
	1A					3A			6A					
	Management activity by primary objective													
	Dispersed recreation (1)	Forage (2)	Wilderness (3)	No management (4)	Developed recreation (5)	Maximum timber (6)	Dispersed recreation (7)	Forage (8)	Maximum timber (9)	Developed recreation (10)	Modified timber management (11)	Dispersed recreation (12)	Forage (13)	
	Units per acre													
1. TIMBER (M fbm)						0.25	0.22	0.24	0.15		0.1	0.12	0.14	= MAXIMUM OBJECTIVE
2. FORAGE (lb)	100	150	100	100	30	125	120	140	250		245	250	275	≥ 7,848,000
3. DEVELOPED RECREATION (visitor-days)					2,000					1,500				≥ 2,000
4. DISPERSED RECREATION (visitor-days)	2	0.5	0.1	0.1		0.5	0.75	0.5	5		6	5.5	0.5	≥ 135,000
5. WATER (acre-ft)	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.0	0.2	0.2	0.2	0.2	0.2	≥ 27,000
6. SEDIMENT (tons)	4	4	3	3	4	5	4.5	5	7	2	6	6	6	≤ 235,000
7. MAXIMUM WILDERNESS (acres)			1											≤ 4,000
8. MINIMUM WILDERNESS (acres)			1											≥ 2,000
9. 1A (acres)	1	1	1	1	1									= 10,000
10. 3A (acres)						1	1	1						= 15,000
11. 6A (acres)									1	1	1	1	1	= 20,000
12. RECREATION ZONE (acres)										-300	1			≥ 0

Figure 1.--Planning unit annual output matrix set up for linear programing for three land units.

many units, though, may create too many activities for the computer to process in a reasonable time period or the computer storage capacity may be exceeded. In other cases, aggregation of present units may result in expected deviations from average values that are entirely acceptable, thus reducing computer and model formulation workloads.

Second, it is assumed that the management program on one acre will not affect the output on a neighboring acre. In the case of timber management this may be fairly true, but a clearcut next to a campground could conceivably affect the number of visitor-days. In some cases, this problem may be surmounted by establishing special constraints to assure buffer zones between incompatible outputs such as was done in figure 1 for developed recreation.

Third, linear programing assumes linearity of coefficients. This means that if 1 acre provides for 5 visitor-days, 10 acres will provide for 50 visitor-days. Again, in the case of timber, water, and forage, this seems to be a reasonable assumption. However, in recreation for instance, a certain number of acres may be required before any visitor-days are produced. In some instances this problem can be solved by breaking the nonlinear relationship into a number of separate linear functions that approximate the original relationship.

Fourth, to keep the model simple and within the limits of available data, the effects of time and investments on the alternatives are ignored. That is, the outputs are expressed in terms of average annual potential rather than potential that varies with time or investment level. Furthermore, model simplification has compelled us to not plan for each acre individually. Thus, actually finding each acre for a particular management activity is not within the scope of the present model. These last two problems, although critical for unit planning concerned with general land allocation over the long run, are not considered within the L-P model and will need to be dealt with after the information available in the L-P solutions is obtained.

Fifth, as previously mentioned, linear programing allows only one objective or goal to be maximized or minimized. In the multiple use management required on National Forests, numerous (often conflicting) objectives exist. One solution to this fifth assumption is a technique called goal programing. For a discussion of other solutions, see Cohon and Marks (1975).

GOAL PROGRAMING FOR MULTIPLE USE DECISIONS

In situations where more than one objective exists, conflicts between the objectives are certain to arise when we seek optimal solutions. Charnes and Cooper (1961) proposed a technique called goal programing (G-P) designed to handle this type of situation. G-P is a unique approach to the problem of trying to achieve a set of simultaneously unattainable goals such as is often found in multiple use management. The approach consists of minimizing the difference between the solution and the goals instead of maximizing or minimizing the objective function in the traditional sense.

G-P has been applied on a few National Forests (Mount Hood, Tonto, Mark Twain). In each case the solution procedure involved specifying levels of production for timber, recreation, range, etc., which would be desirable and the production possibilities for the units of land involved under alternative management schemes. The G-P procedure then was used to allocate land to the various management schemes so as to achieve the desired levels of production as closely as possible. The following discussion outlines in technical terms how G-P may be applied and some of the problems that may be encountered.

There are a number of G-P formulations, but for our purposes an illustration of the linear equation form will be sufficient. Mathematically, this type of goal program can be expressed as:

$$\text{Minimize:} \quad \sum_{i=1}^{n} (w_{1i}d_i^- + w_{2i}d_i^+)$$

$$\text{Subject to:} \quad AX + Id^- - Id^+ = G$$

$$BX \quad \overset{\leq}{\underset{>}{=}} \quad C$$

$$X_j \geq 0 \quad j = 1, \ldots m$$

$$d_i^-, \ d_i^+ \geq 0 \quad i = 1, \ldots n$$

Where: d^-, d^+ = the vectors (n x 1) of the negative and positive deviational variables, respectively. These represent the solution's deviation from the goal vector, G(n x 1).

w_{1i}, w_{2i} = the weights and/or priorities for the deviational variables. Lee (1971) has proposed preemptive ranking, and Dyer (1972) has proposed subjectively determined cardinal scales.

A = the matrix (n x m) representing the relation between the decision variables vector, X(m x 1), and the goal vector, G(n x 1). In practice, the decision variables vector often represents inputs which are transformed by the A matrix to obtain the desired outputs or goals.

I = the identity matrix.

B = the matrix (c x m) of coefficients which relate the decision variables to the constraint vector, C(c x 1).

n, m, and c = the number of goals, decision variables, and constraints, respectively.

APPLICATION OF GOAL PROGRAMING TO LAND USE PLANNING

Several applications of goal programing exist in forestry, beginning with Field's (1973) general article in "Forest Science." Basically, two types of computer programs have been used in these applications, standard L-P and Lee's (1972) G-P. A standard L-P solution package has been used by Rustagi (1973) in analyzing reforestation decisions and by Porterfield (1973) in analyzing genetic programs. This procedure allows only valuing of goals according to their importance without considering pre-emptive priorities. Pre-emptive priorities are a procedure for ensuring that a goal of higher priority is completely satisfied before one of lesser priority is considered. The special G-P program by Lee (1972) allows one to set pre-emptive priorities for the goals in addition to the cardinal values or weights within a given priority level. Thus, Lee's program can do all the L-P version can and more. Unfortunately, the program is restricted to approximately 125 activities, whereas land use planners often develop over 1,000. It also requires considerable storage space and appears to be inefficient in its use of computer time. Modifications by Monteith and Colby (1974) and particularly Bottoms[1] have partially overcome these size and efficiency problems.

The decision to use L-P for goal programing rests on a number of factors. First, L-P solution procedures are readily available whereas Lee's G-P may not be. Second, many land use planning problems are too large even for the expanded version of Lee's program. And finally, the use of pre-emptive priorities can be approximated by appropriate weights.

Application of the L-P solution procedure to goal programing in land use planning is relatively simple. Basically it involves adding an objective function and explicitly recognizing the deviational variables in the matrix formulation. As an example, figure 2 shows the results of this operation on figure 1. For each goal

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[1] Kenneth E. Bottoms, Department of Range Science, Colorado State University, Fort Collins, personal letter, May 12, 1975.

Output	Analysis unit of land									
	1A					3A			6A	
	Management activity by primary objective									
	Dispersed recreation	Forage	Wilderness	No management	Developed recreation	Maximum timber	Dispersed recreation	Forage	Maximum timber	Developed recreation
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Units per acre									
0. OBJECTIVE										
1. TIMBER (M fbm)						0.25	0.22	0.24	0.15	
2. FORAGE (lb)	100	150	100	100	30	125	120	140	250	
3. DEVELOPED RECREATION (visitor-days)					2,000					1,500
4. DISPERSED RECREATION (visitor-days)	2	0.5	0.1	0.1	0	0.5	0.75	0.5	5	
5. WATER (acre-ft)	0.8	0.8	0.8	0.8	0.9	1.0	1.0	1.0	0.2	0.2
6. SEDIMENT (tons)	4	4	3	3	4	5	4.5	5	7	2
7. MAXIMUM WILDERNESS (acres)			1							
8. MINIMUM WILDERNESS (acres)			1							
9. 1A (acres)	1	1	1	1	1					
10. 3A (acres)						1	1	1		
11. 6A (acres)									1	1
12. RECREATION ZONE (acres)										-300

Figure 2.--Planning unit annual output matrix set up for linear programi

row (e.g., rows 1-5 in figure 2), one or two goal columns (e.g., columns 14-18 in figure 2) are added, depending on how deviations from the goal are perceived. If one is concerned only with minimizing underachievement, then the row can be set up as a "greater than or equal to" row and a 1 is placed where the goal row and deviational variable column cross. All the goals in figure 2 are set up in this fashion. Conversely, if one is concerned with minimizing overachievement (not shown), then the row should be a "less than or equal to" row and a -1 placed at the confluence of the goal row and column. If both overachievement and underachievement are to be minimized, then the row should be set up as an "equal to" row and both the plus and minus deviational variables should be added. In figure 2, the other necessary slack and artificial variables needed to achieve the solution are assumed to be added by the L-P computer program.

Finally, row 0 with the weights (e.g., 1,000, 100, 1, 10, and 10 in figure 2) for the deviations from the goals is specified as the objective; and the right-hand-side values for the goal rows are changed as necessary to show the desired output or goal levels. After this operation, the matrix is ready to be run using an L-P computer package to obtain the G-P solution. Alternative solutions may be obtained

Analysis unit of land --Continued			Deviation variables					Right-hand side
6A --Continued								
Management activity by primary objective--Continued								
Modified timber management	Dispersed recreation	Forage	Timber	Forage	Developed recreation	Dispersed recreation	Water	
(11)	(12)	(13)	(14)	(15)	(16)	(17)	(18)	
- - - - - Units per acre - - -			*Value per M fbm*	*Value per lb*	*Value per visitor-day*	*Value per visitor-day*	*Value per acre-ft*	
			1,000	100	1	10	10	= MINIMUM OBJECTIVE
0.1	0.12	0.14	1					≥ 7,000
245	250	275		1				≥ 8,000,000
					1			≥ 2,000
6	5.5	0.5				1		≥ 135,000
0.2	0.2	0.2					1	≥ 27,000
6	6	6						≤ 235,000
								≤ 4,000
								≥ 2,000
								= 10,000
								= 15,000
1	1	1						= 20,000
1								≥ 0

with goal programing slacks and objectives added for three land units.

by varying goal levels, the deviation weights, or both as shown in table 2.

This particular example assumes that the goals are the five rows--timber, forage, developed recreation, dispersed recreation, and water--and that the right-hand-side values in figure 2 express the desired goal levels. Other types of goals could be added. Also, this formulation assumes that we are concerned with underachievement of these goals and that no penalty exists for overachievement.

COMPARISON WITH LINEAR PROGRAMING SOLUTIONS

To place G-P in perspective, it may be useful to compare it with other L-P formulations such as the "Resource Capability System" (USDA Forest Service 1973b) in an abstract sense. L-P will sometimes produce the same answers as those derived from G-P, but formulation of the problem is somewhat different. In both cases, units of output are weighted by relative values. However, with L-P we are concerned with the average value of the units over the range of outputs between zero and what is possible; in G-P, we are concerned with the values of the units that lie between our goals and what is possible.

Table 2--*Alternative goals and weights and their associated outputs*

Type of output	Units	Goal	Alternative weights[1]		
			A	B	C
Goal set 1:					
Timber	M fbm	7,000	6,019	6,375	6,019
Forage	Lb	8,000,000	8,000,000	8,000,000	8,000,000
Developed recreation	Man-days	2,000	2,000	2,000	2,000
Dispersed recreation	Man-days	135,000	135,000	115,752	135,000
Water	Acre-ft	27,000	27,000	27,000	27,000
Goal set 2:					
Timber	M fbm	6,000	5,303	6,000	5,300
Forage	Lb	7,700,000	7,700,000	7,819,875	7,697,375
Developed recreation	Man-days	75,000	75,000	75,000	75,000
Dispersed recreation	Man-days	190,000	147,342	137,875	147,375
Water	Acre-ft	27,000	27,004	27,004	27,004

[1] The weights used for the objective function in column A were 10, 10, 10, 10, and 10 for timber, forage, developed recreation, dispersed recreation, and water, respectively; likewise the weights were 1,000, 100, 1, 10, and 10 for column B and 10, 10, 1,000, 1,000, and 500 for column C.

To the extent that these values are comparable, the two methods may produce similar results even though L-P maximizes the value of the output and G-P minimizes the difference between the goals and the outputs.

Yet, another qualifier must be added before the two methods will produce identical results--the goal used in G-P for a particular output must be close to the value that L-P will choose when it maximizes total benefits. To illustrate this point, look at figure 3 which represents a simple linear programing problem with two outputs, S and T, constrained by lines EF and CD and valued with prices represented by the slope of line AB. If we wish to maximize the value of S and T, we will produce OG units of S and OH units of T and operate at point Z. This is the solution an L-P type of formulation would show. If, for some reason such as political expediency or administrative decree, our goal is to produce OY units of S but none of T, then the G-P solution would be to produce OC units of output S and no units of output T. This solution minimizes the value of the discrepancy between the goal and what is possible if we assume the same price structure. Thus, situations exist where an L-P type formulation will produce a different solution from the G-P formulation even though prices are assumed to be linear with output.

IMPLEMENTATION CONSIDERATIONS

A number of points must be considered in the application of goal programing, but two extremely important ones are the problems of goal setting and weights versus priorities. Other points deal with the G-P portrayal of trade-offs between alternatives and the relationship of G-P to the decision-making framework called "satisficing."

Goal programing minimizes the discrepancy between the goals and their achievement, even when conflicts between goals exist. However, G-P says nothing about which goals or what levels are appropriate. Translating a broad objective such as "satisfying the needs of the Nation" into kinds of outputs and their relative values can be frustrating to say the least, but little help is available.

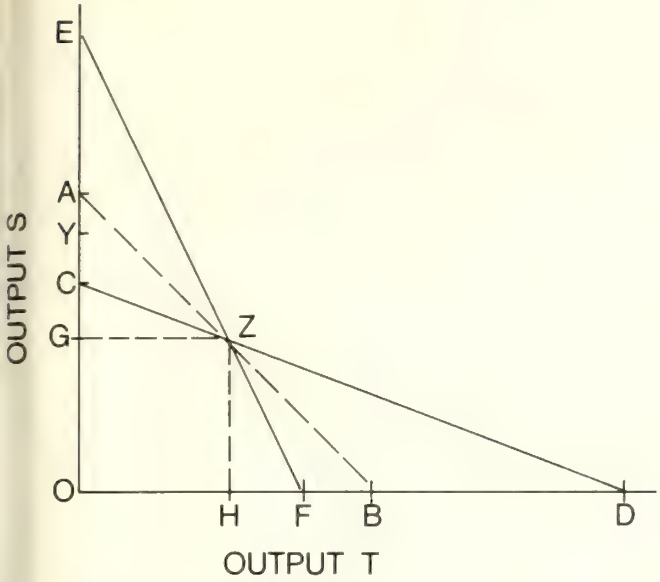


Figure 3.--Linear programing formulation for two outputs.

GOALS

One way of setting the goals is to use the current output figures for the planning unit. This implies that the present situation is ideal, which may not be true. Another way is to solve the matrix with very low goal levels for the important outputs and see what outputs the solution produces. Then these outputs or biological capabilities can be modified by public opinion and the manager's input and can be used as the goals. Finally, the planner can avoid all responsibility by requiring the manager to construct some appropriate goals and their levels. This latter alternative may not be as bad as it sounds since the manager has the responsibility for setting the goals in the first place and is often in the best position to realize the desires of the public. In any case, the goals initially set need not remain fixed for all solutions but may be varied to test the sensitivity of the solution or may be modified if they are shown to be unrealistically low or high.

One caution should be discussed at this point. If goals are less than the possible outputs, then one may get an inferior or inefficient solution; that is, the solution outputs may be less than the maximum outputs for a given set of inputs. Figure 3, which displays a production possibilities curve labeled CZF, illustrates this point. When our goal is to produce OG units of output S and none of output T, then the solution which would be at point G is clearly inferior since we can get more of output S with no additional inputs. To avoid this situation, at least one goal should be set higher than the possible levels.

WEIGHTS

As discussed earlier, Lee's G-P program can handle priorities or weights or both, but the L-P formulation of G-P outlined in this paper can use only weights. In addition to expressing relative values, variations in the weights may compensate for goals stated in various kinds of units. This allows complete freedom to measure each goal in its appropriate unit such as dollars, board feet, acres, and visitor-days.

Priorities: Priorities are used to establish absolute dominance among goals. That is, a goal with a high priority must be satisfied (as far as possible) before any lower priority goals is considered. Contrary to Lee's (1972, p. 22) assumption, the application of priorities is not synonymous with ordinal ranking but requires the assumption that achievement of a high priority goal is more desirable than achievement of even a small amount of the goal at the next lowest priority. Ranking says nothing about the interval between priorities, but the use of priorities in goal programing requires an assumption regarding the interval.

Although the use of priorities relieves the planner of the task of establishing cardinal values for weights, few planners seem willing to let the computer determine the cardinal values. Because of this, some guidelines are needed for the establishment of the alternative method, the use of weights.

The Churchman-Ackoff Technique: One way to obtain relative weights for the deviational variables in the G-P objective is the Churchman-Ackoff (C-A) technique. This technique was originally developed by Churchman and Ackoff (1954) to obtain consistent relative values for alternative outcomes. It has been used subsequently by Turban and Metersky (1971) among others.

This technique, sometimes referred to as "two stage rating," is proposed here primarily because of the success others have had in similar situations. Other techniques classified as "multiple-regression" and "hybrid rating - regression" (see Huber 1974) have been developed. However, the C-A method seems preferable because it provides consistent relative values with minimum effort.

If (1) weights or values do exist, (2) these values correspond to the importance of the outputs, and (3) the addition of values can be associated with the addition of outputs, then the C-A technique is valid. Basically, the procedure which is necessary to develop consistent relative values involves the following process, illustrated by a simple example:

1. Assuming we have four outputs, 0_1, 0_2, 0_3, and 0_4, to value; the first step involves ranking them by preference. In this case we will assume that the subscripts indicate our ranking with the lowest number being the most preferred.

2. The next step consists of associating numerical values with the outputs. The most preferred output is valued at 1.00 and the others are assigned values less than 1.00, according to our relative preference for them. For instance, if a unit of 0_1 is twice as desirable as 0_3, then 0_3 would be assigned a value of 0.5. Through this process we can assign values to 0_2 and 0_4 also. For our example we will initially assign the following unit values (V):

   $V_1 = 1.00$
   $V_2 = 0.70$
   $V_3 = 0.50$
   $V_4 = 0.40$

   where the subscripts correspond to the outputs.

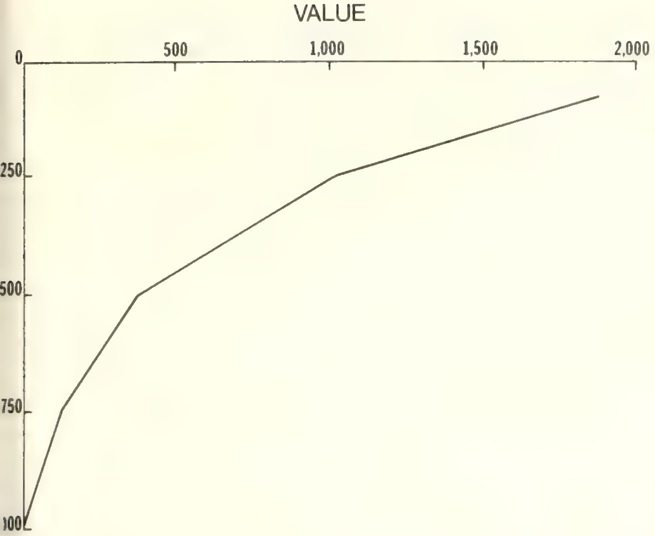
3. Next we must establish that these values are consistent with our true preference scheme, so we compare combinations of outputs. First, we compare 0_1 with $0_2 + 0_3 + 0_4$. If 0_1 is preferred, then V_1 should be greater than $V_2 + V_3 + V_4$. If, as in our example, this is not the case, then adjustments must be made in V_2, V_3, and V_4 while maintaining their relative values. Now $V_1 = 1.00$, $V_2 = 0.40$, $V_3 = 0.25$, $V_4 = 0.15$. If 0_1 was preferred, we proceed to a comparison of 0_2 with $0_3 + 0_4$.

4. If $0_3 + 0_4$ is preferred to 0_2, as in this example we assume it is, further adjustments in the values must be made to make $V_2 < V_3 + V_4$. Now $V_1 = 1.00$, $V_2 = 0.40$, $V_3 = 0.30$, and $V_4 = 0.20$; each value is consistent with our preferences for its associated output. Since this is the final comparison we can make, the procedure is finished for our simple example. In cases where more outputs are considered, the procedure is continued until all the required comparisons have been made.

The values derived from this technique can now be used as the coefficients in the objective function of the G-P formulation, provided some precautions are observed. First, the values are not exact, since the technique allows some latitude in adjustments. Second, the values are relative and not absolute. And finally, the preferences for the outputs must be additive, which is not always the case.

Nonlinear Weights: In the discussion above, we assumed that the weights are linear--that is, the value is directly proportional to the amount of deviation from the goal no matter how much deviation occurs. Goal programing can handle situations in which this is not the case, as the following simple example illustrates.

Consider a situation in which a small deviation from a goal may not be very harmful but a large one may be disastrous. Figure 4 shows a loss function for this type of situation. Here, small deviations from the goal cost only 0.5 point per unit whereas



re 4.--*Objective loss function for goal programing.*

large deviations can cost up to 5.0 points per unit according to the slope of the line.

To set this situation up for G-P, we establish four output goals at different levels with their associated deviational variables (d_1, d_2, d_3, d_4) where "x" is the decision variable and "a" represents the relation between "x" and the output goals.

$$\begin{array}{lr} ax + d_1 & \geq 250 \\ ax + \quad d_2 & \geq 500 \\ ax + \qquad d_3 & \geq 750 \\ ax + \qquad\quad d_4 & \geq 1{,}000 \end{array}$$

The weights for the deviational variables would reflect the loss function and would be incorporated into the objective function.

$$\text{Minimize: } 2.5\ d_1 + 1.5\ d_2 + 0.5\ d_3 + 0.5\ d_4$$

Other constraints and deviational variables could be added in the usual manner.

TRADE-OFFS

Goal programing has been faulted on a number of occasions for its inefficiency in showing trade-offs between alternatives. Cohon and Marks (1975, p. 214) state that the "decision makers are expected to supply the necessary data with no knowledge of what the feasible trade offs embodied in the noninferior set are." By this they emphasize the fact that with G-P the goals and their weights must be established outside the model, often without prior knowledge of possible alternatives.

This problem should have become apparent in the previous discussion on how to establish weights and goals. It can be alleviated only through numerous iterations of the G-P model in which the goals and their weights are allowed to vary. The results of these iterations, which will implicitly show some of the trade-offs, can then be used by the manager in deciding on appropriate weights and goals.

SATISFICING

Simon (1957) has proposed a behavioral decisionmaking model called "satisficing" which is achieving increased emphasis in present day decision models, e.g., Galbraith (1973). Basically, the model depends on the observation that decisionmakers react to uncertainty and lack of information by setting targets which they seek to achieve rather than by maximizing or minimizing an objective. With this model, alternatives can easily be measured in terms of whether or not they achieve the goals. This simple decision framework has great intuitive appeal; circumstantial evidence indicates that it has widespread use by decisionmakers, particularly in planning.

Lane (1970) suggests that goal programing provides a useful representation of the satisficing model which improves on the other representations using either simulation or fixed constraint levels. By requiring that targets or goals be established with penalties for nonachievement, G-P in essence duplicates the important attributes of the satisficing model. Thus, G-P can provide a behavioral approach to decisionmaking in land use planning.

CONCLUSION

Goal programing has generated considerable interest as a tool for land use planning in multiple goal situations. It does present problems in terms of somewhat difficult data requirements--linearity in its usual form, possible inferior solutions, and lack of explicit recognition of tradeoffs. Yet it also presents opportunities for handling complex situations, quickly portraying alternatives, allowing more than one goal, and simulating the satisficing decision framework. G-P has been used on a few National Forests and seems to have provided a useful service to the planners in analyzing their alternatives in these instances. However, it is not a panacea for poor planning and must be used with full recognition of its shortcomings.

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Aerial Application Equipment for Herbicidal Drift Reduction

R.E. Stewart
H. Gratkowski

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Abstract

This publication provides silviculturists and managers of utility rights-of-way with a description and evaluation of available helicopter spray application equipment. Modified conventional equipment will reduce drift of sprays in normal carriers and apply various high viscosity sprays. Specialized spray systems have found limited use in forestry; they are more commonly used on utility rights-of-way. Most of the available spray systems or spray adjuvants reduce but do not completely eliminate drift. Maximum drift reduction with present equipment and adjuvants is obtained with the Microfoil Boom®.

Keywords: Herbicide applications, spraying (-brush control, application equipment, helicopters, silviculture.

PESTICIDE PRECAUTIONARY STATEMENT

Pesticides used improperly can be injurious to man, animals, and plants. Follow the directions and heed all precautions on the labels.

Store pesticides in original containers under lock and key--out of the reach of children and animals--and away from food and feed.

Apply pesticides so that they do not endanger humans, livestock, crops, beneficial insects, fish, and wildlife. Do not apply pesticides when there is danger of drift, when honey bees or other pollinating insects are visiting plants, or in ways that may contaminate water or leave illegal residues.

Avoid prolonged inhalation of pesticide sprays or dusts; wear protective clothing and equipment if specified on the container.

If your hands become contaminated with a pesticide, do not eat or drink until you have washed. In case a pesticide is swallowed or gets in the eyes, follow the first-aid treatment given on the label, and get prompt medical attention. If a pesticide is spilled on your skin or clothing, remove clothing immediately and wash skin thoroughly.

Do not clean spray equipment or dump excess spray material near ponds, streams, or wells. Because it is difficult to remove all traces of herbicides from equipment, do not use the same equipment for insecticides or fungicides that you use for herbicides.

Dispose of empty pesticide containers promptly. Have them buried at a sanitary land-fill dump, or crush and bury them in a level, isolated place.

NOTE: Some States have restrictions on the use of certain pesticides. Check your State and local regulations. Also, because registrations of pesticides are under constant review by the Federal Environmental Protection Agency, consult your county agricultural agent or State extension specialist to be sure the intended use is still registered.

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The use of trade, firm, or corporation names in this publication is for the information and convenience of the reader. Such use does not constitute an official endorsement or approval by the U.S. Department of Agriculture of any product or service to the exclusion of others which may be suitable.

Introduction

Herbicides have been successfully used as aerial sprays to release conifers and prepare planting sites in the Pacific Northwest for more than 20 years. During this time, techniques have been developed and used to reduce spray loss and insure maximum deposition on target areas. Increased public concern about use of pesticides suggests that measures designed to reduce herbicidal drift will be more necessary in the future. Therefore, silviculturists who prescribe and use herbicides on forest lands must become more familiar with factors influencing spray drift and methods available for keeping herbicidal losses at acceptable levels.

Drift hazard from aerial sprays is related to weather conditions during spraying, distance that droplets must fall, and drop size. Spray drift can be reduced by spraying under ideal weather conditions: air temperatures below 75° F, slightly unstable air temperature gradient, relative humidity above 50 percent, windspeed less than 6 miles per hour, and wind direction away from sensitive areas (Gratkowski 1974, Yates et al. 1967). As flying height increases, spray droplets remain suspended longer and are more subject to evaporation and drift. Therefore, flying height should be as low as safety permits, usually 30 to 50 feet above the vegetation.

A major factor influencing amount and distance of drift is spray droplet size. The greatest potential for reducing drift hazard is through reduction or elimination of small (less than 100-micrometer diameter) drift-susceptible droplets. Whenever possible, this should be done by reducing the range of sizes produced rather than by increasing average drop size, since large droplets result in poor plant coverage (fig. 1).

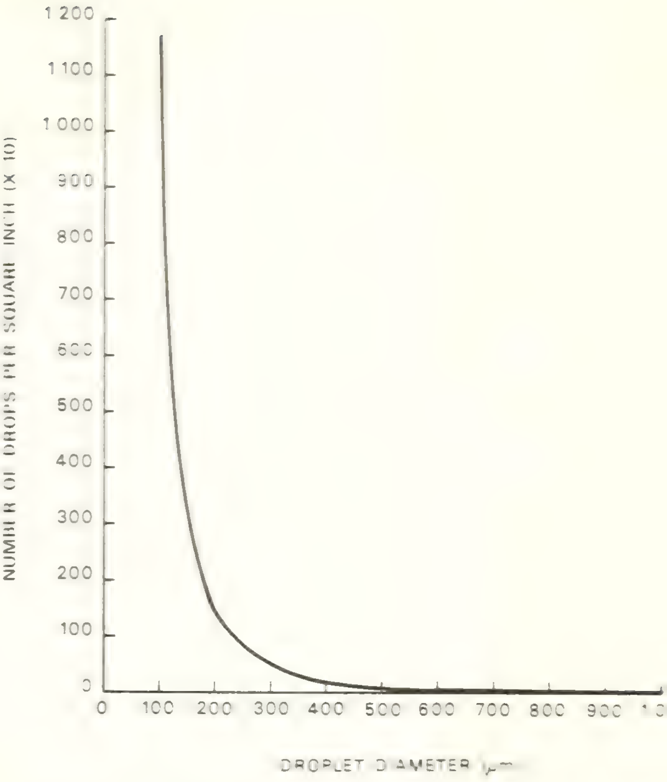

Figure 1.--Relation of droplet size to number of droplets per square inch in 10 gallons of spray.

Liquids must be broken into small drops by a complex process called atomization to obtain good coverage and distribution of the spray. Atomization, and the resulting droplet size distribution, is controlled by physical properties of the spray solution and type and arrangement of the application equipment. Silviculturists can improve spray deposition by selecting herbicidal formulations and adjuvants that reduce volatility and increase spray viscosity and surface tension (Butler et al. 1969, Gratkowski and Stewart 1973).

Selection of proper aerial application equipment is as important as selecting herbicidal formulation. In fact, significant improvements can be made in reducing drift of normal formulations through use of well-designed spray delivery systems. Modifications of conventional application equipment or specialized systems may be necessary for applying high viscosity sprays for maximum drift reduction. This

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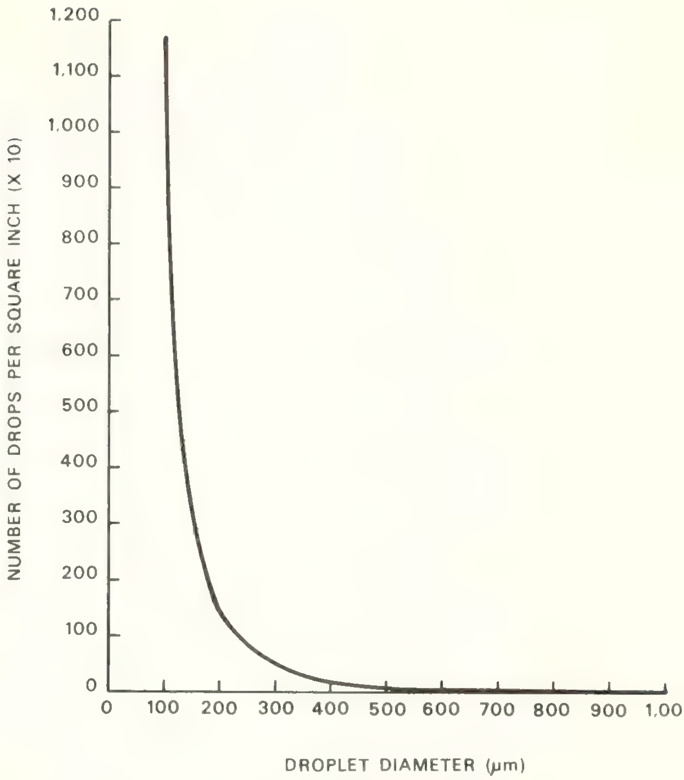

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Selection of proper aerial application equipment is as important as selecting herbicidal formulation. In fact, significant improvements can be made in reducing drift of normal formulations through use of well-designed spray delivery systems. Modifications of conventional application equipment or specialized systems may be necessary for applying high viscosity sprays for maximum drift reduction. This report describes and evaluates helicopter spray delivery systems for applying normal sprays or high viscosity sprays on forest lands and utility rights-of-way.

Aerial Application Equipment

All conventional and most specialized spray application systems have the following parts: spray tank, pump, shutoff valve, pressure gage, spray boom, and nozzles (fig. 2). There are only five factors related to application equipment that can be altered to affect droplet breakup. These are: (1) flying speed, (2) pump pressure, (3) nozzle orifice diameter, (4) nozzle type, and (5) nozzle orientation with respect to the airstream. All modifications of conventional systems and specialized systems designed for application of normal sprays rely on these factors. Additional modifications are necessary to pump and apply high viscosity invert emulsions, particulated sprays, or thickened sprays.

Each application system is designed for use with specific formulations or spray adjuvants (table 1). When drift reduction is not needed for every application, conventional spray systems and tank mix visco-elastic adjuvants like Amchem Products' Lo-Drift® or Nalco's Nalco-Trol® should be used. Such systems are more flexible, readily available, and cost less than specialized application equipment.

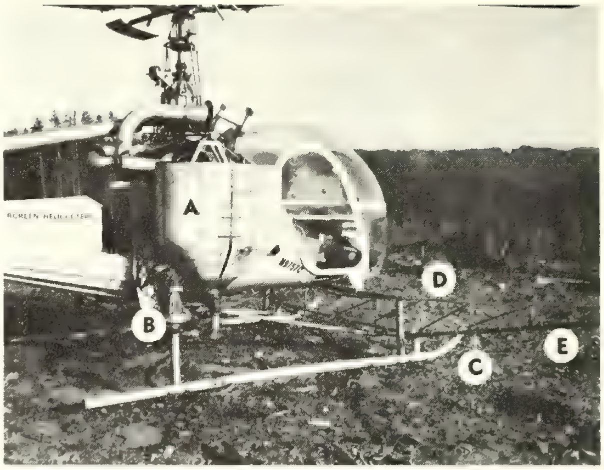

Figure 2.--Conventional aerial spray system: (A) spray tank, (B) pump, (C) pressure gage, (D) spray boom, and (E) nozzles.

Table 1--*Suitability of aerial spray systems for applying different herbicidal formulations and adjuvants*

Aerial spray system	Formulation or adjuvant type					
	Normal spray	Foam spray	Invert emulsion		Particulated sprays	Thickened sprays
			Tank mix	Flash mix		
Conventional	X	X	X		X	X
Microfoil Boom®	X					
Transducer[1/]	X					
Electrostatic[1/]	X					
Dow R-511® and modified R-511			X		X	X
Bifluid® and Visko-Rhap®				X		
Spra-Disk® [1/]			X			

[1/] Not presently recommended for forestry use.

When maximum drift reduction is needed on every acre treated, specialized systems and spray formulations should be considered. For example, Amchem's Microfoil Boom®, experimental transducer systems, or electrostatic systems are designed to reduce drift of normal sprays. The Dow R-511 spray system®, modified R-511, Stull Bifluid®, Rhodia Visko-Rhap®, and Amchem Spra-Disk® are used with thickened sprays, particulated sprays, or invert emulsions (Gratkowski 1974). The Spra-Disk® is not used for forestry, and transducer and electrostatic sprayers are experimental and not presently recommended. These systems are included for information only.

CONVENTIONAL SPRAY SYSTEMS

Normal Sprays

Normal water- or oil-based sprays can be applied with conventional spray tanks, pumps, distribution lines, and spray booms. To reduce drift, it is necessary to reduce the amount of spray in small, drift-susceptible droplets. Conventional hydraulic pressure nozzles shape the spray pattern and produce the initial formation of droplets. A wide range of droplet sizes is formed as a result of droplet-shearing forces produced by turbulence in the nozzle and in the airstream. These are counteracted by droplet-forming forces of viscosity and surface tension of the spray. To reduce droplet breakup, it is necessary to minimize turbulence within the nozzle and airstream.

Shear forces within the nozzle can be reduced by using large orifice nozzles with straight flow internal design and by lowering spray pressures. Six types of hydraulic pressure nozzles are used for aerial spraying: hollow cone with whirl plate, hollow cone with offset entrance (whirl chamber), fan, full cone, cylindrical jet, and flooding nozzles (Akesson and Burgoyne 1967, Bintner 1974). Of these, fan, hollow cone with whirl plate, and cylindrical jet nozzle patterns are most commonly used in forestry (fig. 3).

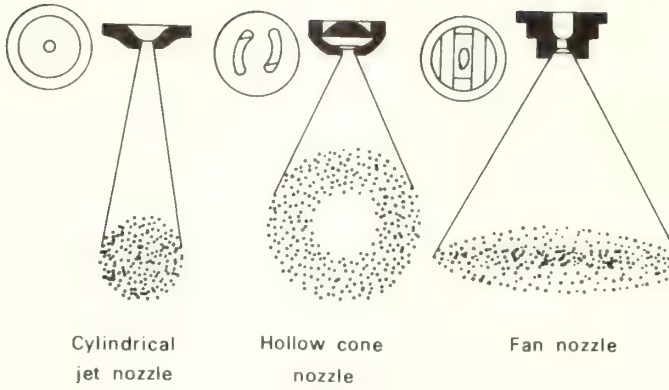

Figure 3.--Design and spray pattern of cylindrical jet, hollow cone, and fan nozzles.

Nozzles producing narrow, cylindrical patterns form fewer small drops and are better for reducing drift. Hollow cone nozzles with whirl plates are especially versatile because both the whirl plate number and disc orifice size can be varied to obtain desired median droplet sizes. It is possible to increase droplet size by using whirl plates that produce narrow cone angles. For example, spray drift can be reduced with Spraying Systems Company hollow cone nozzles by using whirl plate numbers greater than 45 (Akesson et al. 1970, 1971). Maximum reduction is possible by using cylindrical jet nozzles or hollow cone nozzles without the whirl plate that discharge the spray as a narrow solid stream.

Several foam spray systems have been developed for aerial spraying (Gratkowski and Stewart 1973). These systems require an air-aspirating nozzle to inject air into the spray (fig. 4) and special adjuvants to stabilize the air-in-water emulsion formed by the nozzles. Foam-generating nozzles should be operated at a minimum of 40 pounds per square inch (psi) pressure measured at the nozzle. Nozzles should discharge straight back along the airstream or no more than 30° from horizontal to obtain best drift reduction. Because the adjuvants do not increase spray viscosity, only the nozzles

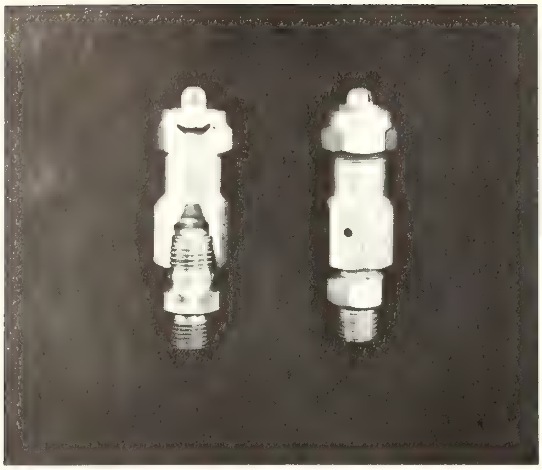

Figure 4.--A foam-generating nozzle.

of a conventional spray system need to be changed to apply foam sprays. Foam-generating nozzles inject a fixed amount of air into the spray depending on individual design. Moreover, each adjuvant will stabilize only a narrow ratio of air to water. Therefore, it is important to use only the nozzle specified by the manufacturer of the foam adjuvant (table 2).

Recent studies strongly suggest that drift-reducing benefits claimed for foam sprays are due to the coarse atomizing nozzles used rather than the foam itself (Akesson et al. 1972, Bouse and Leerskov 1973). In fact, addition of the foaming agent reduces surface tension of the spray and may form drift-susceptible clusters of air bubbles. Foam adjuvants expand spray volume two to seven times. This expansion, plus improved sticking and spreading due to surfactant properties of the foam adjuvants, may compensate for reduced plant coverage caused by the coarse spray. This possible effect is the only justification for using foam sprays.

The Delavan Manufacturing Company recently developed a new nozzle for reducing drift of normal sprays applied at usual operating pressures of 35 to 40 pounds per square inch. The Raindrop® nozzle produces a hollow cone pattern with droplets that are significantly larger than those produced by conventional nozzles at comparable pressures and flow rates (fig. 5). Furthermore, the amount of spray under 100 micrometers is sharply reduced. For example, the mass

Table 2--*Characteristics of foam-generating nozzles used in aerial spraying.*

Nozzle name	Spray pattern	Recommended foam agent	Range of nozzle outputs at 40 pounds per square inch
			Gallons per minute
Accutrol® aerial coarse	Multiple jet	Accutrol	0.75-1.50
Foamspray® aerial W[1]	Single jet	Foamspray	.23-1.39
Foamspray® Row Crop[2]	Flat fan	Foamspray	.77-1.39
DFA Dela-Foam®	Single jet	Fomex	.77-7.10
Foamjet®	Single jet	None	.60-3.00

[1] Used at airspeeds above 60 miles per hour.

[2] Used at airspeeds below 60 miles per hour.

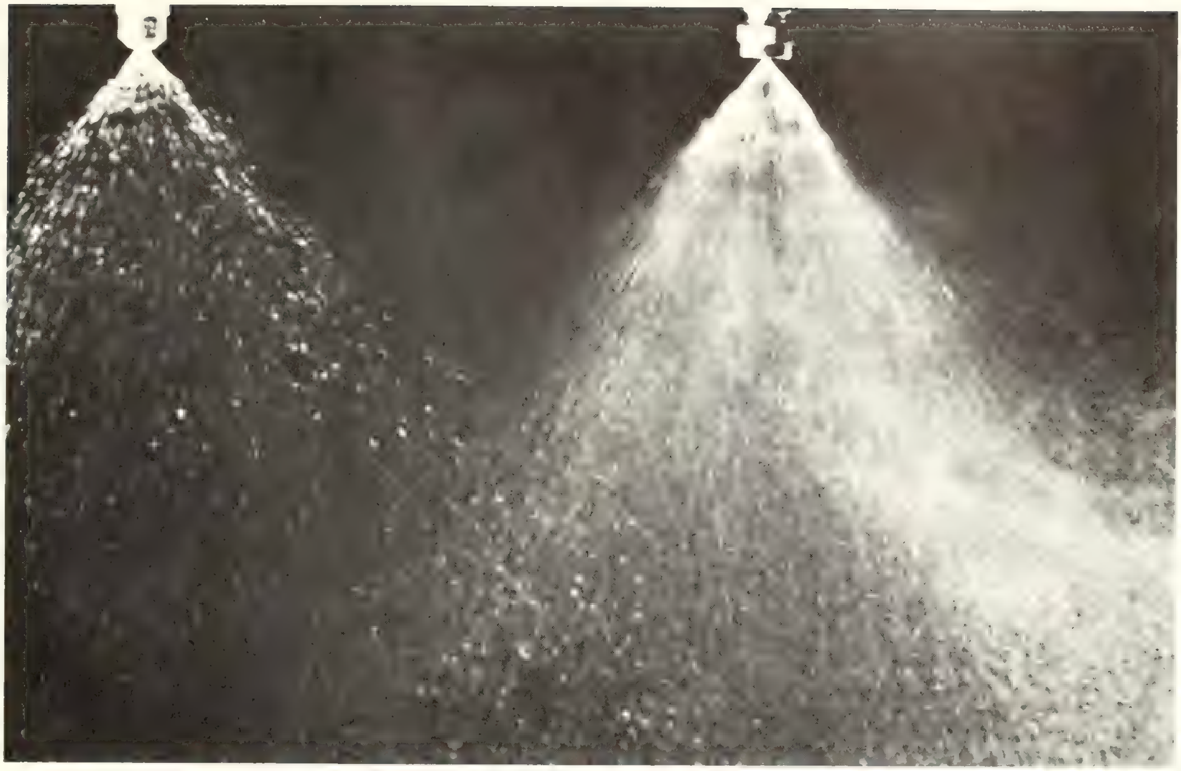

Figure 5.--Comparison of spray pattern from Raindrop® (left) and hollow cone (right) nozzles (4 m/h crosswind).

median diameter[1] (MMD) of droplets produced by a Delavan hollow cone DC4-25 nozzle is 195 micrometers at 40 pounds per square inch with 16 percent of the spray volume in droplets under 100 micrometers (Delavan Manufacturing Company n.d.). In contrast, a Raindrop® 4-25 nozzle produces droplets with a MMD of 410 micrometers and less than 1 percent of the volume under 100 micrometers.

By lowering spray pressure, it is possible to further reduce droplet breakup. However, pressure must be reduced as much as four times to double the average droplet size produced by fan and hollow cone nozzles (Akesson 1952, Akesson and Burgoyne 1967). Since flow rates also decrease with reduced pressure, reducing spray pressure probably has little significance for standard spray nozzles within the operating limits imposed by desired application volume and other conditions. This may change in the future with additional development of special low pressure (10 pounds per square inch or less), high flow rate nozzles such as made by Spraying Systems Company (Bouse et al. 1976).

Droplet breakup occurs after the spray is discharged from the nozzle and subjected to additional shear forces in the airstream. These forces are reduced as discharge velocity and direction approach that of the airstream itself. Therefore, flying speed and nozzle orientation are major factors affecting droplet breakup outside the nozzle (Isler and Carlton 1965, Brandes 1966). However, the effect of reduced flying speed on droplet breakup is insignificant within the narrow range, 45 to 60 miles per hour, necessary for the small helicopters used in forestry. More variation is possible with larger helicopters operating above

---

[1] Mass median diameter (MMD) or volume median diameter (VMD) is the drop diameter that divides the spray volume into two equal parts. In other words, 50 percent of the spray volume is in droplets larger or smaller than the MMD.

60 miles per hour or with fixed-wing aircraft operating above 90 miles per hour.

In contrast, nozzle orientation has a major influence on droplet breakup. **Changing nozzle orientation from straight down to directly back along the airstream can increase median droplet size by 150 percent** (fig. 6).

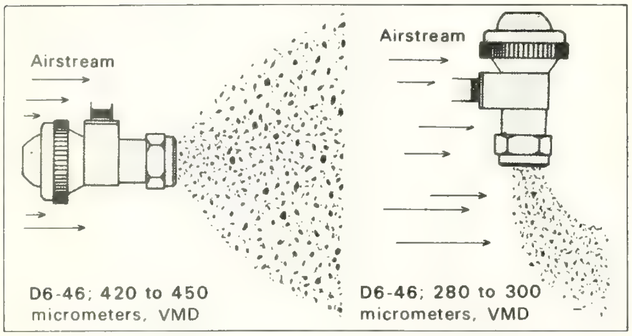
Airstream
Airstream
D6-46; 420 to 450 micrometers, VMD
D6-46; 280 to 300 micrometers, VMD

Figure 6.--Variation in droplet size resulting from change in nozzle orientation. (Adapted from Brazelton (1971); used with permission of University of California Division of Agricultural Sciences.

Intermediate degrees of droplet breakup and drift reduction can be obtained by adjusting the nozzles to discharge back at 30° or 45° from horizontal. Nozzle orientation can be easily changed by using fixed-angle elbow connectors, streamlined booms, or round spray booms. Streamlined booms are designed so that nozzles may be located on the top, bottom, and low-turbulence trailing edge of the boom (fig. 7). Round spray booms can be clamped to the helicopter skid toes and then rotated to change nozzle orientation by loosening the clamps. Fixed-angle spray bodies, swivel connectors, or vari-spacing nozzles are available but not recommended.

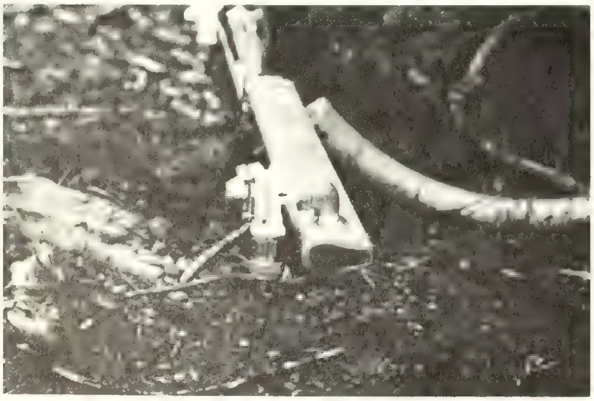

Figure 7.--Nozzles can be attached on the top, bottom, or trailing edge of a Simplex Manufacturing Company streamlined boom.

There are several advantages in using conventional rather than specialized spray equipment. Commercial applicators usually have the necessary parts in stock. Spray tanks, pumps, distribution lines, and spray booms do not have to be modified for applying herbicides in normal water, oil-in-water emulsion, or oil carriers. By selecting nozzle type, nozzle orientation, and flying speed, foresters can obtain a suitable droplet size distribution for desired degree of drift control and plant coverage. Therefore, conventional spray systems are less expensive, more flexible, and more readily available than specialized systems or adjuvants. Furthermore, at airspeeds below 65 miles per hour, drift control with D8 jet nozzles (8/64-inch diameter orifice) directed back along the airstream using normal sprays is similar to that obtained with thickened sprays (Butler et al. 1969).

Foresters can obtain maximum drift reduction with normal spray formulations and conventional application equipment by using D8 jet nozzles directed back along the airstream at minimum safe flying height. Additional reductions may be possible with Delavan Raindrop® nozzles operated at standard pressure or Spraying Systems LP® nozzles operated at low pressure. More droplet breakup and better plant coverage but less drift reduction are obtained from hollow cone nozzles with whirl plates that produce narrow cones which are oriented between 45° and straight back along the airstream.

Even with these modifications, a wide range of droplet sizes will still be produced. The smaller drops result in better plant coverage but drift will occur; 2 to 15 percent of the spray volume may be deposited beyond 1,000 feet downwind from the application (Akesson et al. 1972). However, close adherence to weather, flying height, and flying speed restrictions can minimize these losses.

High Viscosity Sprays

Thin tank mix invert emulsions and other low to moderate viscosity sprays can be applied with conventional spray systems. For most applications, jet nozzles directed straight back or no more than 45° from horizontal should be used to minimize droplet breakup. Minimizing shear forces is especially important with viscosity-elastic polyvinyl polymers such as Amchem Products' Lo-Drift® or Nalco's Nalco-Trol®. Adjuvant rates as low as 8 to 16 ounces per 100 gallons may be possible if Lo-Drift® or Nalco-Trol® sprays in water carriers are applied through jet nozzles directed back along the airstream; rates up to 32 ounces per 100 gallons may be necessary with other nozzles or nozzle orientation or with emulsion carriers.

Thick tank mix invert emulsions and other high viscosity sprays can be applied through modified conventional spray systems. All modifications are the result of the increased viscosity and are similar for invert emulsions, thickened sprays, or particulated sprays.

Thick sprays flow more slowly than normal sprays. Therefore, the spray distribution system must have a larger capacity to produce the same flow rates as normal sprays. Crossover lines between helicopter saddle tanks should be about 4 inches in diameter. Pump suction lines should have a diameter at least as large as the pump inlet port and should draw from the center of the crossover line between tanks. Delivery lines to the boom and the boom itself should be 1-1/2 to 2 inches in diameter, and enough lines must be provided from pump to boom to maintain even pressure at all nozzles. Suction and supply lines must be as short as possible, with a minimum number of turns.

Standard centrifugal pumps cannot produce sufficient flow rates with viscous sprays. Therefore, gear (1-1/2 inches or larger), piston, or vane positive displacement pumps should be used. Pump capacity must be at least 30 percent greater than for normal sprays. High capacity centrifugal pumps can be used, but they must be operated in a flooded condition. **With most invert emulsions, pumps must move the required volume without creating additional shear, or the emulsion will become thicker. Pump output must be matched to nozzle output to minimize recycling and additional shearing of the emulsion.**

As with normal formulations, droplet size distribution of thickened sprays is affected by spray pressure, nozzle tip design, orifice size, nozzle orientation, and flight speed. Nozzles with simple internal design and large orifice diameters are necessary for application of highly viscous sprays. If nozzle strainers are used, they should be coarse-meshed--generally 50 mesh or larger. For most forest spraying with viscous sprays, D8 (8/64-inch diameter orifice) or D10 (10/64-inch orifice) jet nozzles directed 45° or straight back will produce adequate flow rates and good drift control. With Norbak® particulated sprays, it may be necessary to use lower rates of adjuvant and nozzles directed downward or 45° back to obtain some breakup and reasonable spray coverage (Butler et al. 1969).

High viscosity sprays will produce volume median diameters between 800 and 5 000 micrometers when applied through D8 jet or other straight stream nozzles directed down at airspeeds less than 60 miles per hour or back along the airstream at higher speeds (Akesson et al. 1972). However, the range of droplet sizes produced is still relatively large, with 1 or 2 percent of the spray volume in small, drift-susceptible droplets.

As with normal sprays, maximum drift reduction with invert emulsions, Vistik®, Dacagin®, Lo-Drift®,

Nalco-Trol®, and Norbak® applied through modified conventional equipment will be obtained if: (1) jet nozzles are used, (2) nozzles are directed back along the airstream, (3) aircraft speed is reduced, and (4) pump pressures are reduced. A lower flying height will further reduce drift, but swath coverage will also be reduced. Therefore, *normal flying heights of 30 to 50 feet above the vegetation should be used in applying high viscosity sprays.*

SPECIALIZED SPRAY SYSTEMS

The Microfoil Boom® and various transducer spray systems were designed to reduce drift of normal sprays. The Microfoil Boom® reduces drift by increasing median drop size and decreasing the range of droplet sizes produced; while transducers decrease only the range of drop sizes. The electrostatic system seeks to reduce drift by electrically charging the spray stream and using the electrical potential of the earth's surface to attract the spray droplets. Although theoretically possible, this system has failed to demonstrate reduction in drift.

The R-511®and modified R-511 spray systems were designed to overcome problems in pumping and applying high viscosity spray mixtures. The Bifluid® and Visko-Rhap® systems were designed to mix and apply flash mix invert emulsions (Gratkowski 1974, Gratkowski and Stewart 1973). The Spra-Disk® was developed to apply tank mix invert emulsions with minimum droplet breakup when flying high above powerline rights-of-way.

Microfoil Boom ®

The Microfoil Boom®, developed by Amchem products, Inc., combines the advantages of low pressure, straight flow jet nozzles, and proper nozzle orientation to obtain large, nearly uniform size droplets (Kirch 1968). Spray is circulated through two parallel booms which help to equalize pressure and flow to each nozzle (fig. 8). To reduce droplet breakup, a 40-pounds per square inch spray pressure in the boom is reduced to only 2 pounds per square inch at the nozzle orifices.

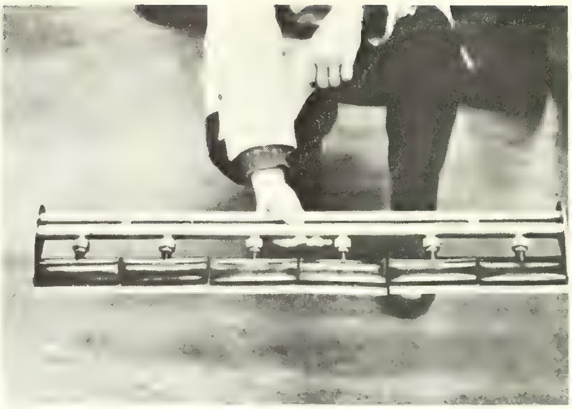

Figure 8.--The Microfoil Boom ® circulates spray through two parallel booms to equalize pressure and flow to each nozzle.

Microfoil nozzles are shaped like an airfoil to produce laminar or smooth airflow and minimum turbulence at the point where spray droplets form (fig. 9). Each nozzle is 6 inches long and contains

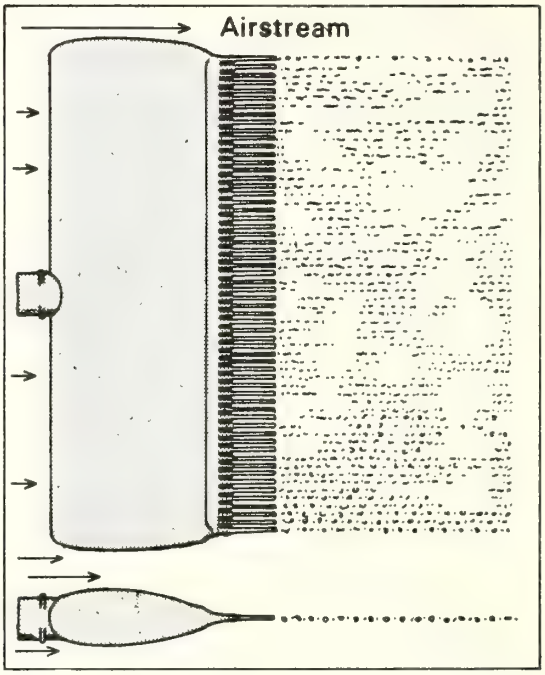

Figure 9.--Microfoil nozzles have an airfoil-shaped body with needlelike orifices protruding from the training edge. (Adapted from Brazelton (1971); used with permission of University of California Division of Agricultural Sciences.)

a row of sixty 0.013- or 0.028-inch diameter needlelike orifices along the trailing edge of the airfoil. Two other special nozzles are available for the Microfoil Boom®. The first was developed for forestry use and consists of three rows of 0.013-inch orifices delivering 10 gallons of spray per acre at 60 miles per hour. The second, termed a "hay-rake" nozzle, was developed for application of sprays at heights of up to 400 feet above powerlines. Each nozzle contains a single row of 0.060-inch orifices that produce very large diameter droplets (fig. 10).

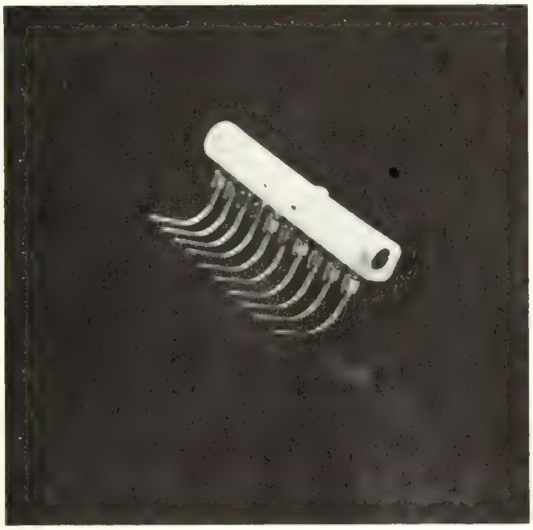

Figure 10.--A Microfoil ® "hay-rake" nozzle with 0.060-inch orifices.

Microfoil nozzles produce droplets of two distinct sizes, primarily as a result of a process called Rayleigh breakup (Wilce et al. 1974). Primary droplets are about twice the size of the orifice diameter. Smaller satellite droplets are formed from thin filaments of spray between the primary droplets. If the nozzles are properly oriented with the airstream, these smaller droplets are recaptured by the larger ones in the smooth air flow behind each nozzle. For maximum drift reduction, the boom must be continually leveled with the airstream by means of a pilot-oriented control unit as a helicopter changes flight attitude. When properly leveled, the 0.013- and 0.028-inch Microfoil nozzles produce droplets of 800 and 1 700 micrometers, respectively, with a variation of only ± 200 micrometers. Only the smaller 0.013-inch diameter orifice should be used for forest or rangeland spraying. The Microfoil should be used only at airspeeds below 60 miles per hour; excessive droplet breakup occurs at greater airspeeds.

The spray boom is assembled in sections and can be varied in length from 10 to 26 feet to obtain swath widths between 10 and 70 feet. Fine mesh tank truck and saddle tank filter systems are necessary to prevent clogging of the orifices. Therefore, high viscosity sprays and wettable powders cannot be applied through the Microfoil. Furthermore, extra care must be taken to prevent debris from entering spray tanks. This can be done by covering nurse tank and saddle tank openings and by using fine mesh screens in water draw hoses, pump lines, and nozzles. Nozzles should be removed and cleaned frequently with a spray-pik tooth cleaner or similar device.

Other problems that developed in operational spray tests on the Siuslaw and Siskiyou National Forests can be minimized or eliminated by the following actions:

1. Use high-volume electric or hydraulic pumps and manifolds on Hiller helicopters. On Bell helicopters, use Amchem's special hydraulic pump supplied with the Microfoil.
2. Because the boom is mounted near the ground (fig. 11), use a raised landing pad (e.g., railroad ties) and a level helispot to prevent damage to the boom.
3. Use nozzle bodies made from polypropylene plastic that are less subject to cracking than the original plastic nozzles.
4. Use negative pressure or suckback devices to prevent draining of the nozzle bodies after shutoff in flight.

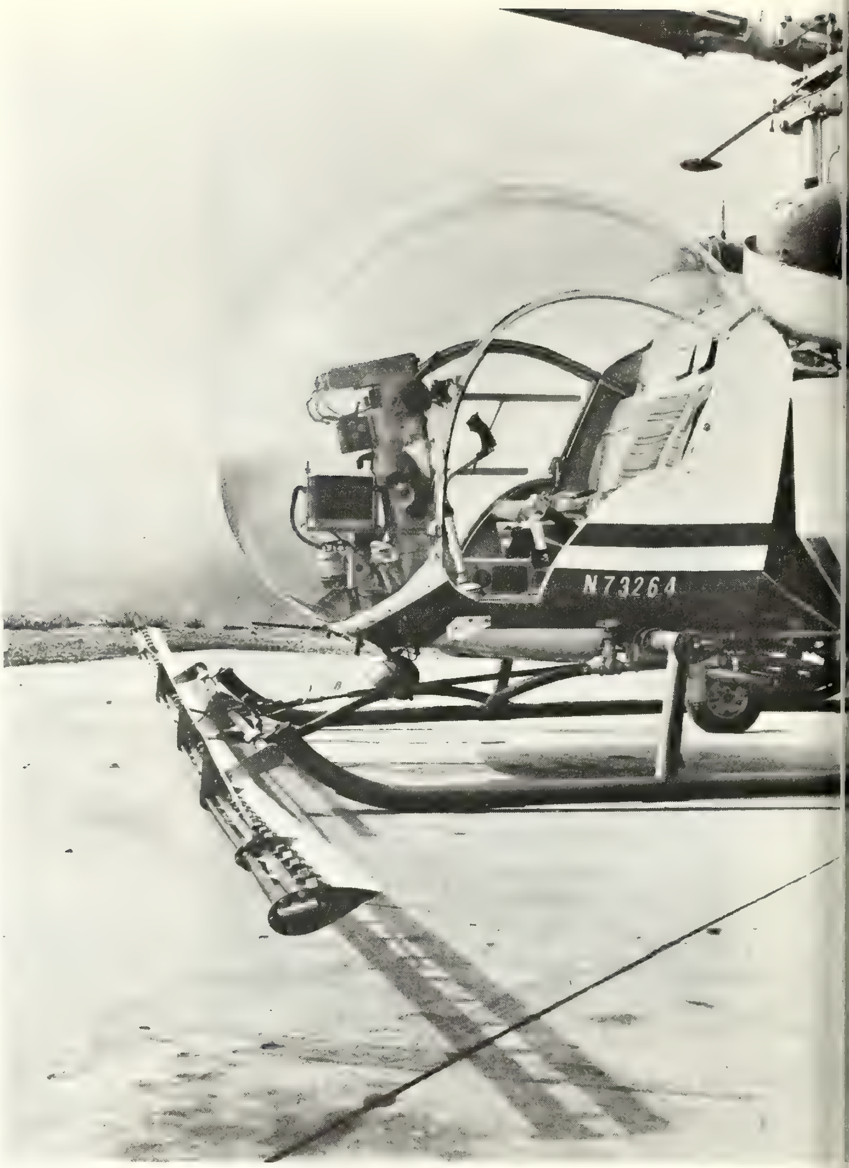

Figure 11.--The Microfoil Boom® is mounted in front of and below the skid toes where it is subject to damage.

The Microfoil Boom® is expensive to buy and maintain. Therefore, few applicators have access to one. The spray swath is well defined and falls directly below the helicopter and behind the pilot in a sheetlike pattern (fig. 12). Skips and poor coverage are common unless the pilot is experienced and can maintain at least a 5-foot swath overlap. Because of poor coverage produced by even the smallest diameter orifices, experience on two National Forests suggests that the Microfoil Boom® should not be used to apply budbreak sprays on deciduous species. Too little spray is intercepted by the leafless stems and branches to obtain good brush control. For foliage sprays, degree of brush control with the Microfoil can be equivalent to or somewhat less than that obtained with conventional booms.

The Microfoil Boom® provides the best drift control possible at this time. In aerial spray tests, 98 to 99 percent of the spray volume was deposited within the desired swath width (Akesson et al. 1971). **If maximum drift reduction is a primary concern, the increased costs and difficulties with the Microfoil Boom® may have to be accepted.**

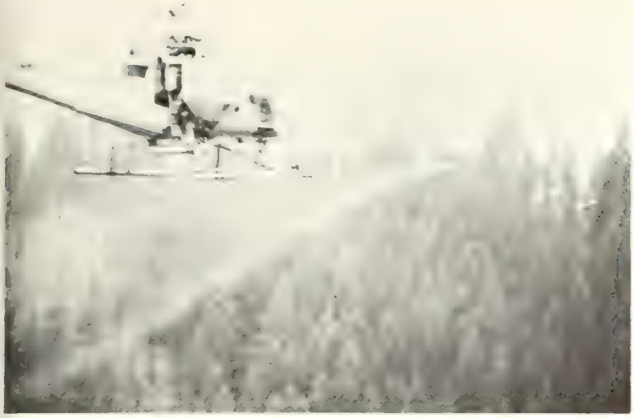

Figure 12.--If the Microfoil Boom® is maintained in proper trim, the spray falls in a characteristic sheetlike pattern.

Transducer Spray Systems

Transducer spray systems use conventional spray equipment except for specially designed nozzles. Within each nozzle, a cyclic pulse is applied to the pressurized stream of spray ahead of the orifice by means of a vibrating magnetized rod or piezoelectric crystal (fig. 13) (Bouse et al. 1974, Roth 1971, Wilce et al. 1974). This vibration causes droplets to form at the applied frequency. For example, 6,000 drops per second are formed at a vibration rate of 6,000 times per second. As long as external vibrations from pumps or other equipment do not cause the vibrations to become out of phase, the resulting drops are uniform in size due to the regularity of the applied pulse. Droplet formation becomes irregular if secondary pulses occur.

Drop size is determined by the size of the orifice used, pump pressure, and applied frequency. Since small diameter jet orifices are used, droplet size is about twice the orifice diameter. An increase in pressure will increase droplet diameter by increasing the volume of liquid flowing between pulses. To minimize shear forces

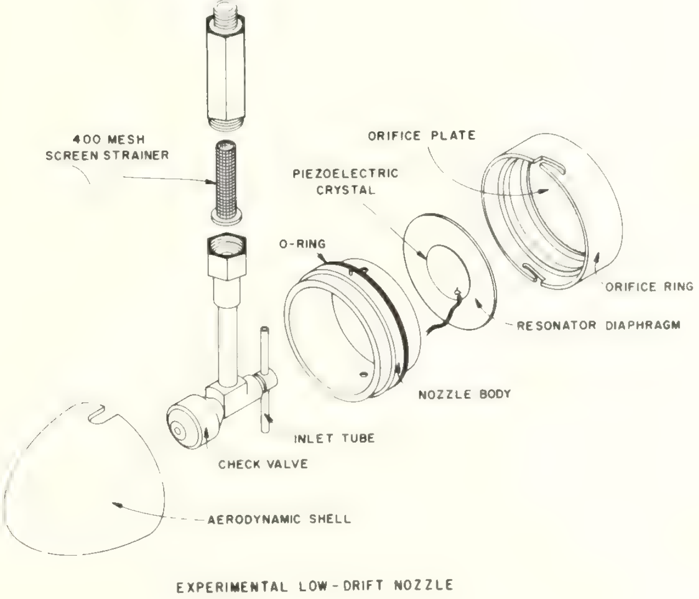

Figure 13.--Transducer nozzles using vibration of a piezoelectric crystal to pulse the stream (Wilce et al. 1974, reproduced with permission).

the nozzles are oriented to discharge along the airstream (fig. 14). By varying orifice diameter, pulse frequency, and pump pressure, droplet sizes suitable for application of different herbicides can be produced.

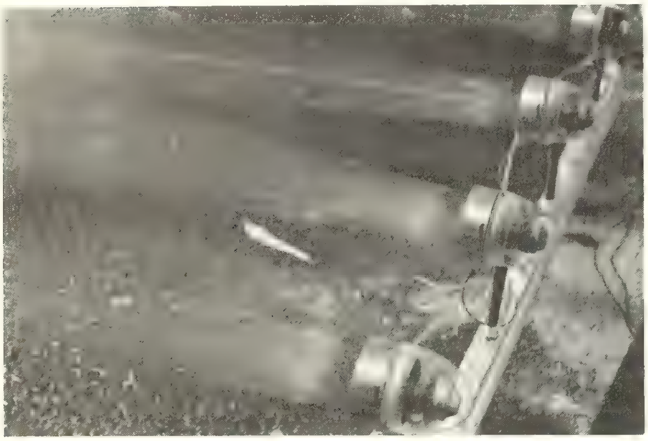

Figure 14.--Multiple orifice transducer nozzles are directed with the airstream to reduce droplet breakup (Wilce et al. 1974, reproduced with permission).

Experimental transducer systems have been built by Cotton, Inc., part of the United States Cotton Council, Texas A & M (Bouse et al. 1974), and University of California at Davis (Wilce et al. 1974). All of these produce drops of about 200- to 300-micrometer diameter, with none below 75 to 100 micrometers and few above 300 micrometers. This smaller droplet diameter provides better plant coverage at normal application volumes while also providing drift reduction similar to that obtained with the Microfoil Boom® (Wilce et al. 1974). Because of the very small orifice diameter, prefiltering and fine mesh line and nozzle filters must be used to prevent clogging. As with the Microfoil, *high viscosity sprays and wettable powders cannot be applied through transducer nozzles.* Flow rates through small orifices are very low so multiple-orifice nozzles may be necessary to obtain adequate flow rates.

Based on limited tests, transducer systems may prove the most effective means to reduce drift and still obtain good pest control (Wilce et al. 1974). However, they are not commercially available and must be evaluated more thoroughly before they can be recommended for operational spraying.

Electrostatic Systems

Electrostatic spray systems are based on the principle that positively charged spray particles will be attracted to the negatively charged surface of the earth and to image-negative plants. One experimental system uses an electrostatic spinner mounted on the wing in place of a spray boom and nozzles to impart a negative charge to the spray droplets as they leave the aircraft (Agricultural Research 1966).

A second electrostatic system, developed by ElectroGasDynamics, Inc., uses a standard spray boom and nozzles and spray gun-type induction generators mounted on the tail of fixed-wing aircraft (Agricultural Chemistry 1971). The generators impart a negative charge to a fine stream of water injected into the airstream behind the aircraft, leaving the airframe positively charged. This positive charge on the airframe is then transmitted to spray droplets as they leave the nozzles.

Benefits claimed for electrostatic systems include reduced drift, increased plant coverage, and lower application rates. However, these claims have not yet been substantiated in objective spray tests (Threadgill 1973). Therefore, **the ElectroGasDynamics system or other electrostatic sprayers are still experimental and cannot be recommended for forestry use at present.**

R-511® and Modified R-511 Spray Systems

In 1966, the Dow Chemical Company introduced the R-511 Spray System® for helicopter application of high viscosity Norbak sprays on rights-of-way (Reimer et al. 1966). Although it is no longer commercially available as a complete unit, many applicators use either the R-511 or a locally modified version of it. Either system can apply any high viscosity spray except flash mix invert emulsions. However, only modified R-511 systems have proved useful for forest spraying (fig. 15).

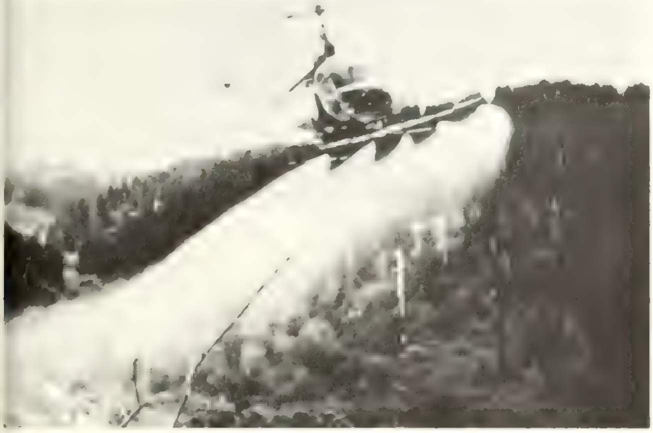

Figure 15.--Modified R-511 system applying Vistik-thickened sprays on the Siuslaw National Forest.

The R-511 Spray System® uses a cluster of five nozzles at the center of an 8-foot support boom (fig. 16). Thickened sprays are drawn from the bottom of the saddle tanks through a suction filter and 2-inch suction line to a positive displacement vane or gear pump. The spray then flows through a series of pilot-operated spray control units and separate 1-inch supply lines to each nozzle. By selecting nozzle pairs, adjusting spray pressure, and changing discharge angle of the nozzle cluster, the pilot can vary swath width from 25 to 50 feet while in flight and still maintain a constant application rate per acre (Reimer et al. 1966).

The Dow Chemical Company also developed a modified R-511 Spray System for applying thick tank mix invert emulsions. This system is similar to the R-511, except that the nozzle cluster is replaced by three nozzles evenly spaced along the 8-foot boom. All three nozzles are angled back to reduce breakup of the spray by the airstream. However, the two outside nozzles are also angled outward to increase swath width. This partially offsets the benefits of directing the nozzles back.

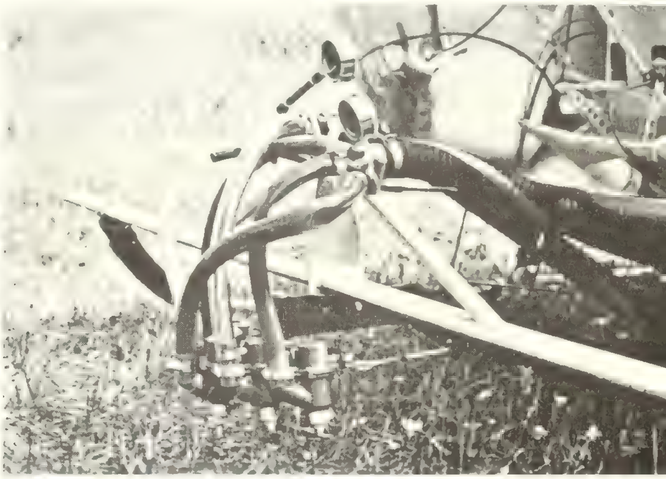

Figure 16.--The Dow R-511® Spray System.

The Dow Chemical Company is now testing a boomless sprayer for rights-of-way.[2] A Spraying Systems Company cylinder manifold is mounted on an R-511 nozzle body attached to each skid toe (fig. 17). Each manifold is 6-1/2 inches long with seven outlets at 10° spacings around the perimeter along its length. Jet nozzles, usually with 00-30 tips, are used in each outlet. Guide vanes in each nozzle reduce turbulence created as the spray turns the corner between the manifold and nozzle. Diaphragm check valves may be used on each nozzle to provide more positive spray shutoff. Manifolds are mounted facing forward

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[2] Personal communication from C. A. Reimer, the Dow Chemical Company, Midland, Mich.

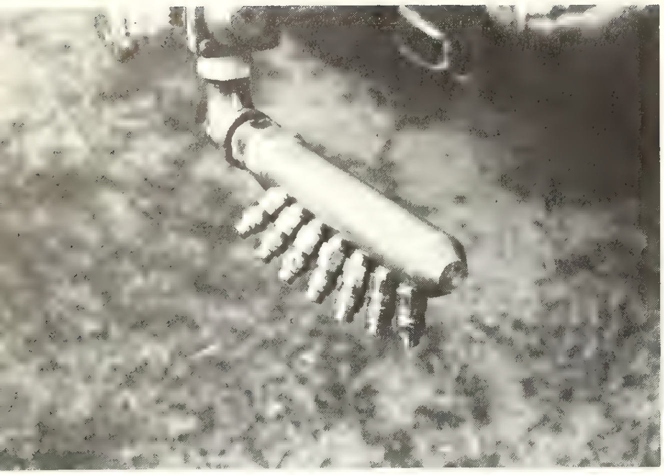

Figure 17.--A boomless sprayer uses cylinder manifolds mounted on the helicopter skid toes.

with nozzles directed outward to produce a 50-foot swath. Some recent versions include a three-nozzle manifold between the skids to obtain better coverage under the helicopter and permit wider swaths. The boomless spray unit results in better spray breakup and more uniform pattern than the R-511 or three-nozzle modified R-511 systems. However, its usefulness has not yet been demonstrated in forest spraying.

Local modified versions of the R-511 Spray System® have been developed. For example, typical units consist of a 2-inch diameter streamline 8-foot boom mounted on the helicopter skid toes.[3] Five nozzles are equally spaced along the boom with a flat fan nozzle at the center and two offcenter[4] nozzles to either side (fig. 18). A positive displacement vane or gear pump is used to move high viscosity sprays through two separate large diameter supply lines to the boom.

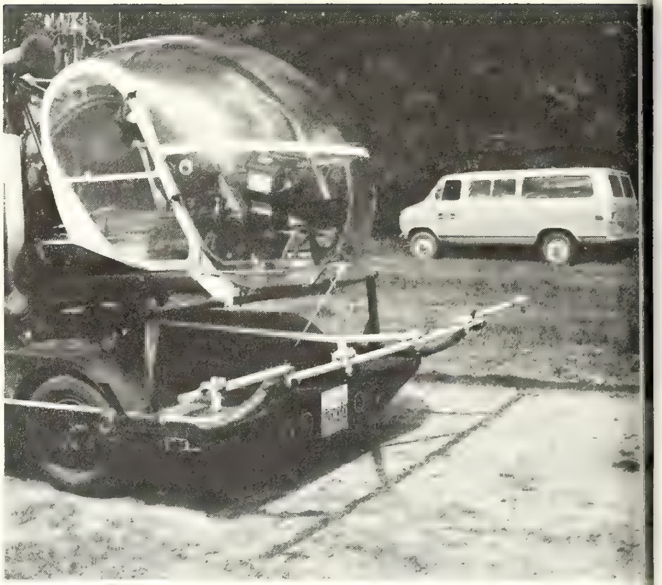

Figure 18.--A modified R-511 system with five nozzles arranged on a short spray boom.

To obtain reasonable swath widths with all versions of the R-511 Spray System®, offcenter nozzles are used. These nozzles broadcast the spray over a greater area than conventional nozzles. Therefore, plant coverage and droplet size may be less uniform near the swath edge than directly under the helicopter.

Bifluid Spray Systems

Bifluid spray systems are used with special herbicidal formulations to both mix and apply flash mix invert emulsions (Gratkowski and Stewart 1973). Only two systems are commercially available: the Stull Chemical Company Bifluid Spray System®, available as individual parts from Stull, and the Rhodia Visko-Rhap Spray System®, available as a complete unit from the Simplex Manufacturing Company. Both systems have the same essential features. They differ mainly in the location where the invert is formed

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[3] Personal communication from Norm Parker, Western Helicopter Services, Inc., Newberg, Oreg.

[4] Offcenter nozzles produce a fan-shaped pattern that is directed down and to the side to obtain maximum swath width.

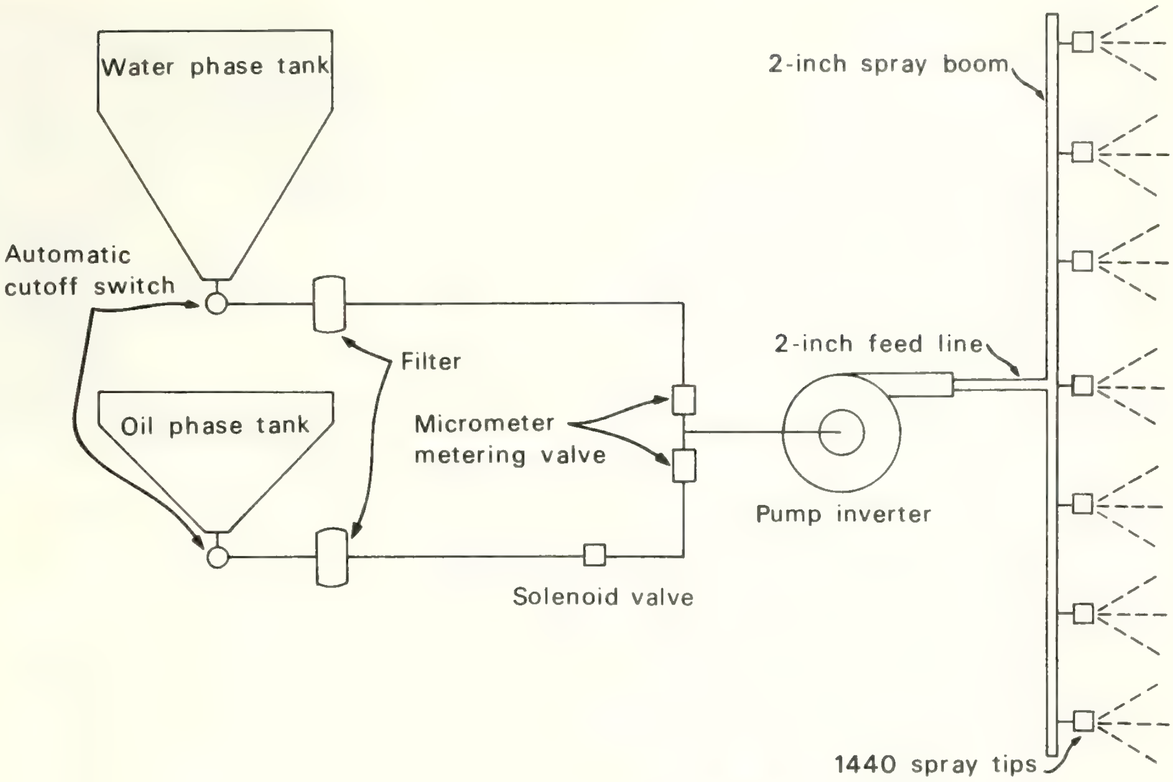

Figure 19.--Diagram of Rhodia Visko-Rhap® Spray System.

and on the method for adjusting flow rate from each tank (fig. 19).

Separate spray tanks are required for the water phase and the oil-herbicide mixture. Because more water is used than oil-herbicide mixture, the water tank should be two to four times larger than the oil-herbicide tank. Formation of the invert emulsion occurs in the centrifugal pump of the Visko-Rhap System® and in a separate mixing chamber on the suction side of a gear pump in the Bifluid System®. Since thickened sprays cannot be returned to the spray tanks, a loop bypass around the pump is used to equalize pressure. Automatic valves shut off the flow from both tanks if either one is empty. Large mesh screens are used to prevent blockage of orifices or valves used to meter the output from each tank.

The Stull Bifluid Spray System® uses special metering orifices to regulate the flow from each tank. Because viscosity of invert emulsions depends on the water-to-oil ratio, viscosity and sprayer output are varied by changing the metering orifices. Any aerial spray nozzle with sufficient output and simple internal design, such as D8 or D10 jet nozzles, can be used.

The centrifugal pump inverter of the Visko-Rhap Spray System® has an output of 20 to 65 gallons per minute controlled by micrometer valves in the supply lines from each tank. Viscosity is easily adjusted by changing the valve settings. The boom is equipped with 40 special

1440 spray tips; each tip has fourteen 0.040-inch jet orifices. For lower application volumes or smaller droplet sizes, 1040 (ten 0.040-inch orifices) or 1432 (fourteen 0.032-inch orifices) spray tips are available. The Visko-Rhap System® is designed for use on fixed-wing aircraft or on helicopters with Lycoming engines; the Simplex Manufacturing Company also builds special bifluid kits for other aircraft.

Bifluid systems have several advantages: (1) formation of the invert emulsion occurs automatically in flight, elminating premixing and handling of thickened sprays; (2) herbicide, oil, and water are metered directly into the mixing chamber, assuring a known constant viscosity; and (3) viscosities can be varied for different spraying conditions by changing metering orifices or micrometer valve settings. However, bifluid systems still allow some drift; 1 percent of the spray volume may be in droplets below 200 micrometers in diameter (Hoffman and Haas 1970, Phillips 1963). Distribution of sprays across the swath can also vary greatly, and plant coverage is reduced (Hoffman and Haas 1970, Lehman et al. 1964). Further, final viscosity of the invert emulsion is somewhat dependent on pH of the water used.

Spra-Disk®

In the late 1950's, Amchem Products, Inc., developed the Spra-Disk® for helicopter application of thick tank mix invert emulsions (Kirch et al. 1960). With this system, inverts flow by a combination of gravity and pump suction through large diameter hoses from the spray tanks to the center of a hollow spinning disc mounted between the helicopter skids (fig. 20). As spray enters the disc, it is forced through 12 jet nozzles around the disc perimeter by centrifugal force. A rheostat operated by the pilot controls disc speed. By varying disc speed, flying height, and airspeed, the pilot can obtain swath widths between 20 and 50 feet.

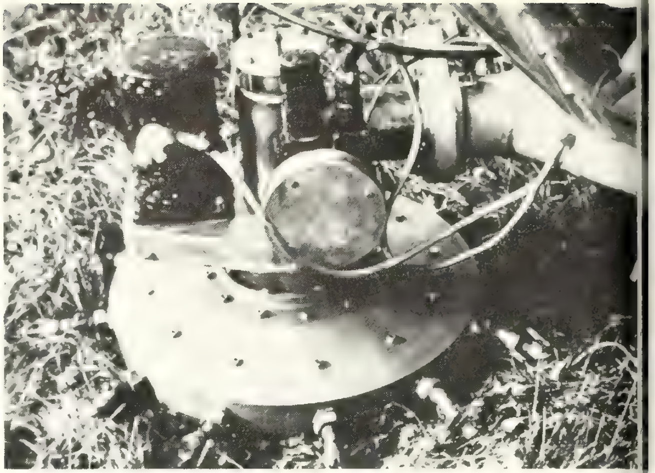

Figure 20.--Amchem's Spray-Disk ®.

A long-bodied nozzle is used at the higher disc speeds required to produce 30- to 50-foot spray swaths. A shorter nozzle is used for swath widths between 20 and 35 feet. With the shorter nozzle, disc speed must be increased to obtain the same velocity attained at the tip of the longer nozzle. This increased speed produces desired droplet breakup and sufficient centrifugal force in the disc to maintain constant flow.

The Spra-Disk® is designed for use at airspeeds between 20 and 30 miles per hour. Sprays have been applied on utility rights-of-way at heights up to 300 feet above the vegetation. At normal flying speed and height, application volume can be varied from 18 to 25 gallons per acre by increasing disc speed. Lower volumes are obtained by decreasing the number of nozzles.

Amchem Products, Inc., leases the Spra-Disk® to aerial applicators that use Amchem's invert emulsion formulations. Because Amchem Products, Inc., services and periodically calibrates the equipment and produces the specific formulations used, calibration data supplied with the Spra-Disk are very accurate and require only occasional field checks by the applicator. Unfortunately, the Spra-Disk® produces a wide range of droplet sizes, but very few are less than 1 000 micrometers in diameter. [5] This is much too large for good vegetation control on forest lands.

Availability of Spray Equipment

Availability of spray equipment from commercial applicators who responded to a February 1973 questionnaire is shown in table 3. This information should help foresters, public utility managers, and others using herbicidal sprays in locating commercial aerial applicators familiar with specific types of equipment. However, the applicator must know what types of equipment or changes in equipment are anticipated prior to the start of spraying. Most do not bring extra equipment into the field unless arrangements have been made.

Because of increased interest in drift control, types of equipment and numbers of applicators using specialized equipment will probably change in the future. Most applicators will use more flexible spray systems because of the high cost and limited use of specialized systems.

Conclusions and Recommendations

All available drift control methods reduce the volume of spray in small, drift-susceptible droplets. However, none of them completely eliminate drift. Moreover, the advantages of more accurate spray placement are not without cost. As droplet size increases, spray coverage decreases. Therefore, efforts to reduce drift may result in decreased herbicidal effectiveness unless herbicidal dosage or spray volume are increased (Behrens 1957, Buehring et al. 1973, Ennis and Williamson 1963, McKinlay et al. 1972).

Drift reduction is desirable near streams and other ecologically sensitive areas. However, the use of specialized application equipment and herbicidal formulations or adjuvants will increase the cost of treatment. Because swaths are narrower and well defined, skips will be more likely and the pilot will have to make more passes to obtain good coverage. Use of specialized spray equipment and adjuvants does not reduce the need for good supervision of the spray operation. Nor does it allow relaxing of weather restrictions during spray application.

Fortunately, maximum drift reduction is rarely necessary in the remote areas typically treated in forestry. Drift reduction is generally needed intermittently near specially sensitive areas. Therefore, more flexible spray systems and adjuvants are desirable. Based on present technology and information, the following types of herbicidal application equipment are recommended:

1. For maximum flexibility where good vegetation control and good spray placement are desired, use conventional spray equipment with D8-46 hollow cone or D8 jet nozzles or equivalent directed 30° to 45° back and airspeeds below 50 miles per hour.

2. For increased drift reduction with little sacrifice in flexibility or spray coverage, use D8 or equivalent jet nozzles directed straight back with the airstream. Future research may show than Delavan Raindrop® or Spraying Systems LP® nozzles will be more useful (Bouse et al. 1976).

3. For good drift reduction and flexibility but some reduction in coverage, use D8 jet nozzles directed back with the airstream and 16 to 32 ounces of Lo-Drift® or Nalco-Trol® per 100 gallons of spray. If drift reduction is only required intermittently, the adjuvant may be added to individual spray loads in the saddle tanks.

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[5] Personal communication from J. Waldrum, Amchem Products, Inc., Ambler, Pa.

Table 3--*Availability of specialized spray equipment from commercial aerial applicators as of February 1973*

Applicator and location	Normal sprays		High viscosity sprays						Foam sprays
	Conventional boom	Microfoil boom®	Modified conventional boom	Spra-Disk®	Bifluid Systems[1]	Dow R-511®	Modified R-511	Mixing equipment	Foam nozzles
Arizona Helicopters, Inc., Scottsdale, Ariz.	X	X	X	-	SP	-	-	-	-
Cascade Helicopters, Inc., Cashmere, Wash.	X	-	X	-	S	-	X	X	X
Coastal Ag Chem, Oxnard, Calif.	X	X	X	X	-	-	-	X	X
Coombs West-Air Company, Yakima, Wash.	X	-	-	-	-	-	-	-	X
Evergreen Helicopters, Inc., McMinnville, Oreg.	X	X	X	X	SP	X	X	X	X
Farm and Forest Service, Napavine, Wash.	X	-	-	-	-	-	X	X	X
Helicopter Services, Yakima, Wash.	X	-	X	X	P	X	X	X	X
Inter-Mountain Helicopters, Inc., Boise, Idaho	X	-	X	-	S	-	-	X	-
Mid-Valley Helicopters, Inc., Jefferson, Oreg.	X	-	X	-	-	-	X	-	X
Omniflight Helicopters, Inc., Janesville, Wis.	X	X	X	X	-	X	X	X	X
Rambling Rotors, La Grande, Oreg.	X	-	X	X	-	-	-	-	X
Reforestation Services, Inc., Salem, Oreg.	X	-	X	-	-	X	X	X	X
Rocky Mountain Helicopters, Provo, Utah	X	-	X	-	P	X	X	-	-
Sky Choppers of Utah, Inc., Provo, Utah	X	-	-	-	-	-	-	-	-
Western Helicopter Services, Inc., Newberg, Oreg.	X	X	X	-	-	-	X	X	X

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[1] S = Stull Chemical Company Bifluid® Spray System; P = Visko-Rhap® (Rhodia, Inc.) Pump Invert System.

4. For maximum drift reduction where flexibility and coverage are less important, use a Microfoil Boom® with 0.013-inch diameter orifices. The Microfoil can only be used for foliage sprays. Further, it may be necessary to increase spray volumes from the normal 8 to 10 gallons per acre to 15 to 20 gallons. Additional research may show transducer systems provide adequate drift reduction and better coverage than the Microfoil (fig. 21).

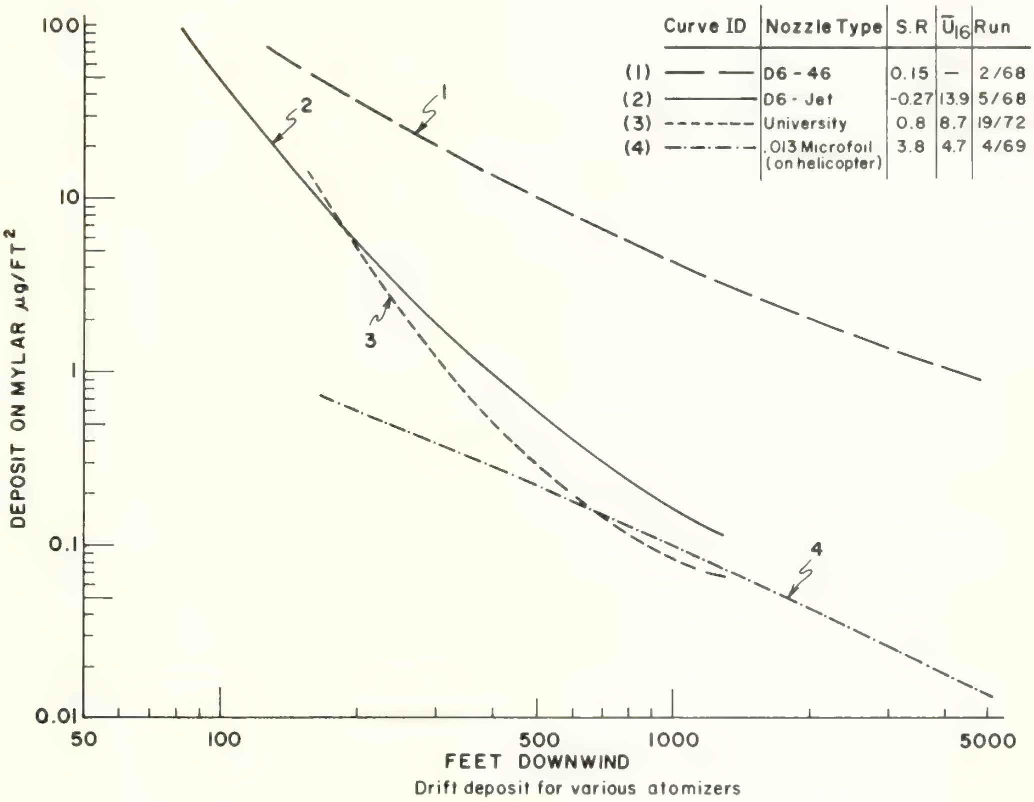

Figure 21.--Comparison of drift downwind from aerial sprays applied through D6-46 nozzles, D6 jet nozzles, transducer system of the University of California at Davis, and a Microfoil Boom® (Wilce et al. 1974, reproduced with permission).

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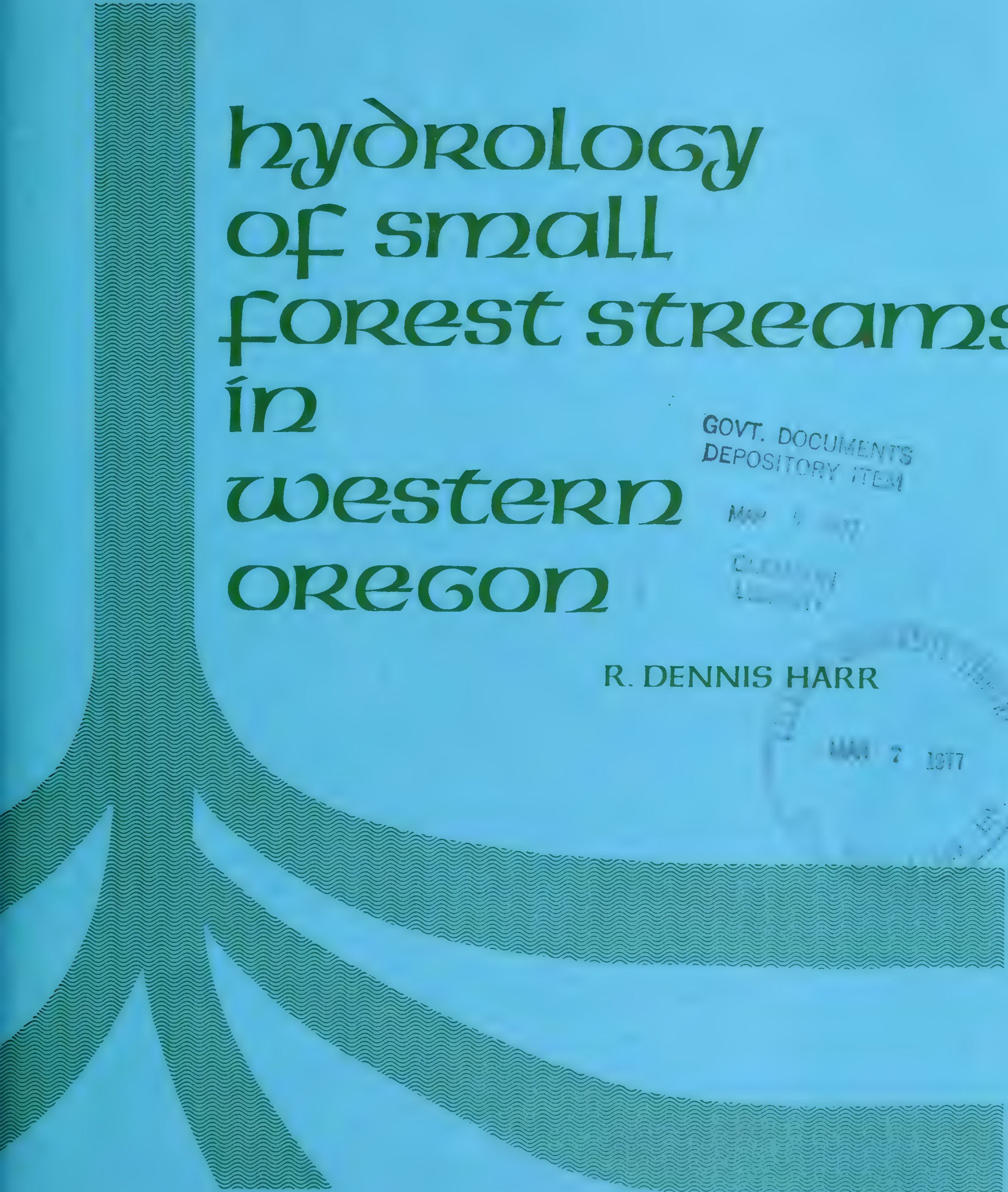

hydrology of small forest streams in western oregon

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Abstract

The hydrology of small forest streams in western Oregon varies by time and space in terms of both streamflow and channel hydraulics. Overland flow rarely occurs on undisturbed soils. Instead, water is transmitted rapidly through soils to stream channels by displacement of stored soil water. Drainage networks expand and contract according to the interaction between precipitation characteristics and soil's capability to store and transmit water. Drainage networks are more extensive in winter than in summer. Streamflow may be 1,000 to 5,000 times greater during winter storms than during summer low flow. A stream's kinetic energy varies along with streamflow. Channel width and depth, heterogeneity of bed materials, and the accumulation of large, organic debris affects the dissipation of kinetic energy. Clearcutting can increase relatively small peak flows, but forest roads and extensive areas of soil compacted by other means may increase larger peak flows. Both roadbuilding and clearcutting can cause soil mass movements which can drastically alter a stream's channel hydraulics by adding debris or scouring the channel to bedrock. Removal of naturally occurring organic debris that has become part of a stable channel can accelerate bed and bank erosion.

KEYWORDS: Streamflow, runoff cycle, clearcutting (-streamflow.

This paper was presented at the Workshop on Logging Debris in Streams, Oregon State University, Corvallis, September 9-10, 1975.

Introduction

Small forest streams are a valuable resource of the Pacific Northwest. High quality stream water is used by municipalities and agriculture. Small streams also serve as spawning and rearing areas for anadromous fish and habitat for resident trout. These streams originate in and flow through highly productive forests whose wood products are vital to the economy of the Pacific Northwest. In many cases, the value of these small streams lies primarily in their effect on downstream waters, a fact recognized by Oregon's Forest Practices Rules (State of Oregon 1974). Moreover, the quality and quantity of water in these small streams may be drastically altered by forest land management practices (Brown 1973).

DEFINITION OF SMALL STREAM

Small streams are those in headwater areas where most streamflow originates. Small streams in western Oregon refers to streams of orders 1, 2, and 3. The order number reflects the stream's position in a drainage network. The smallest streams are designated order 1 (fig. 1). They have no surface tributaries and are either intermittent or permanent. Where two first-order streams join, a channel segment of order 2 begins, and so forth until the highest order channel segment is formed. Some of the small streams in the H. J. Andrews Experimental Forest are shown in figure 1. In this drainage network the highest stream order is 5. This stream (Lookout Creek) flows into Blue River (order 6), which in turn flows into the McKenzie River (order 7), a major tributary of the Willamette River. There are conservatively 250,000 small stream channel segments in western Oregon totaling several hundred thousand miles and collectively draining more than 80 percent of our forest land.

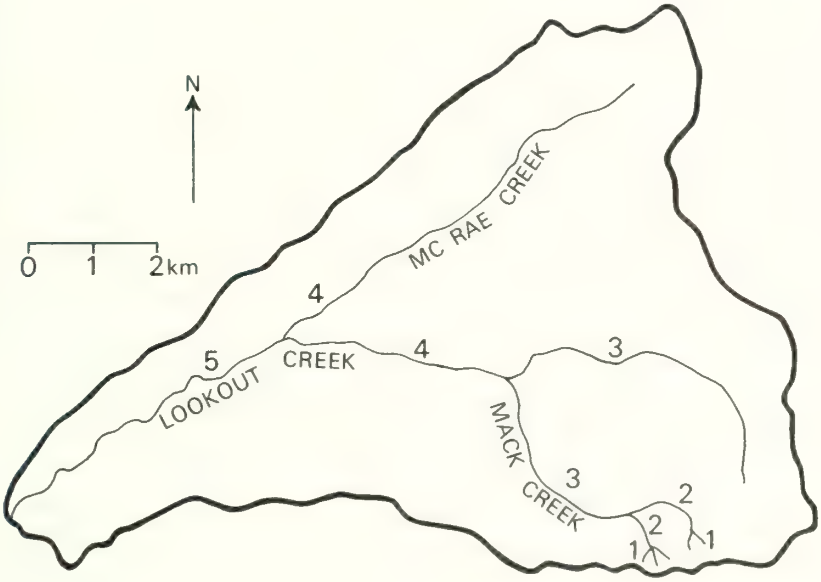

Figure 1.--Stream order numbers of some small streams in the H. J. Andrews Experimental Forest near Blue River, Oregon. Not all small streams are shown.

THE REGION

The climate of western Oregon is influenced by the proximity of the Pacific Ocean. Winters are cool and wet, and summers are warm and dry. Over most of the region, precipitation occurs mainly as rain in frequent, long-duration, low- to moderate-intensity frontal storms. About 75 percent of annual precipitation occurs between October 1 and April 1. Elevations above 915 m (3,000 ft) receive much of their annual precipitation in the form of snow. Frontal storms interact with topography to provide annual precipitation in excess of 300 cm (120 in) on the west side of the Coast Ranges and the Cascade Range. The lower limit of annual precipitation for most forest watersheds in this region is about 50-75 cm (20-30 in).

The topography of most forest land in western Oregon is steep. This topography reflects the nature of the climate, primarily the large amounts of precipitation and its influence on runoff and erosion. Much of the land is highly dissected, and many slopes are extremely steep. These steep slopes exert a major influence on rapid movement of water to streams and through a stream system.

If there is a term that can most appropriately be applied to the hydrology of small, forest streams, it is "variability," not only in streamflow and hydraulic characteristics but also over time and space. This report should make it clear that variability is the rule rather than the exception. It is essential to keep variability in mind while attempting to develop and apply guidelines for managing forest lands without damaging water resources.

Subsequent sections of this report deal with the processes involved in streamflow production, channel flow and associated hydraulic characteristics, and the effects of timber harvesting activities on streamflow. The information presented applies mainly to rain-dominated hydrologic systems and is based largely on results of hydrology studies conducted in western Oregon. Similarities in climate, vegetation, and physiography indicate that, with few exceptions, these hydrologic processes also apply to watersheds in western Washington and the northern coast of California where rain is the dominant form of precipitation.

Hydrologic Processes

Streamflow is generated mainly by processes operating outside the stream channel. Thus, when discussing the hydrology of a small stream, it is imperative to include the hydrology of that stream's watershed. Although the latter is far from being completely understood, bits of information can be assembled to describe what most likely occurs during runoff production--the multitude of processes which collectively transform precipitation to streamflow.

FOREST HYDROLOGIC CYCLE

It may be helpful to briefly review the various processes influencing runoff production for a rain-dominated system (fig. 2). Rain falling on a forest is

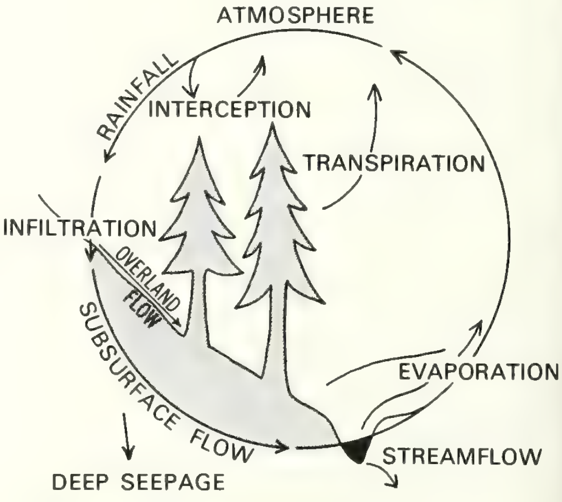

Figure 2.--Rain-dominated hydrologic cycle.

subject to interception by vegetation surfaces. Some of this intercepted water evaporates, while the remainder falls to the forest floor. The relative amount of rain evaporated depends on the size and duration of the storm producing the rain. For example, in an old-growth Douglas-fir forest, Rothacher (1963) found that nearly 100 percent of storms less than 0.13 cm (0.05 in) was intercepted and evaporated, but less than about 5 percent of storms totaling more than 20 cm (8 in) was intercepted and evaporated. In other words, the larger the storm and the longer it lasts, the smaller the proportion of rain lost to evaporation.

Interception not evaporated falls to the forest floor along with rain not initially intercepted. On the forest floor water is subject to infiltration. Depending on the difference between the rate of water arrival at the soil surface and the soil's infiltration capacity or ability to allow water to enter, some water enters the soil and some may become overland flow. In undisturbed forest soils in western Oregon, infiltration capacities far exceed the maximum rates of rainfall so that all water enters the soil. Overland flow rarely occurs where forest soils are undisturbed. Lack of overland flow is one of the most important characteristics of undisturbed forest land in the Pacific Northwest as well as in most forested regions with a humid climate.

Once in the soil, water is subject to gravitational and capillary forces that cause it to move and frictional forces that tend to restrict movement. Because of the slope of most forest land and because soil conductivity generally decreases with depth, water entering the soil begins to move downslope as it moves deeper into the soil. The direction and rate at which water moves depends on rainfall rates and soil properties. Both rate and direction vary considerably over the course of a storm (Harr 1977). Maximum velocities of soil water are low and frequently about equal to the average rate of rainfall during a storm.

Relatively slow-moving soil water is subject to evaporation and to removal by plants through the process of transpiration. The rate at which plants withdraw water from the soil is largely a function of energy available for water vaporization in leaves and the ease with which water may be withdrawn from the soil. As soil moisture decreases during the growing season, remaining water becomes more tightly held by the soil. As the growing season progresses, many plants exhibit reduced rates of transpiration and in some cases transpiration may cease altogether.

Streamflow, on an annual or longer basis, is the difference between precipitation and the evaporation losses described above. There are changes in soil moisture storage from time to time. Some water may also seep deep into the subsoil and bedrock and not appear as streamflow in a small headwater basin. But generally, water not removed by plants moves downslope to supply streams. It is this movement to stream channels that we want to examine in more detail.

COMPONENTS OF STREAMFLOW

At any given time and place, streamflow is comprised of water from channel interception (i.e., rain falling directly on the water surface or streambed within a channel), overland flow, and subsurface flow. Although streamflow cannot be separated into distinct quantities from these different sources, relative amounts of water from these sources can have a great influence on the time distribution of water arriving at the stream channel and the watershed outlet. Classical hydrology has been characterized by its emphasis on overland flow and the importance of the difference between rates of precipitation and infiltration on the generation of streamflow. In well-vegetated areas with humid climates, however, overland flow is the exception rather than the rule (Hewlett and Hibbert 1967). In western Oregon, overland flow in undisturbed forests rarely occurs. If flowing water is observed in this region, it almost always will be in relatively well-defined channels or over seriously disturbed soils such as those in roads, skid trails, or severely burned areas. In undisturbed areas, infiltration capacities of soils are extremely high and, in many cases, may be several hundred times greater than maximum sustained rates of rainfall (Dyrness 1969, Ranken 1974, Yee 1975, Harr 1977). With the low- to moderate-intensity storms common to western Oregon, it is highly unlikely that an undisturbed soil would not accept all water delivered to it as rainfall. Moreover, soils are able to transmit water rapidly, such that overland flow over saturated soils is also highly unlikely (Harr 1977, Yee 1975). The lack of overland flow leaves channel interception and subsurface flow as the only sources of water flowing in stream channels.

TRANSLATORY FLOW

Small streams in western Oregon respond quickly to rainfall, even in the absence of overland flow, which is by far the most rapid process of water movement. For example, in the H. J. Andrews Experimental Forest, maximum rates of runoff have approached 80 percent of the average rate of rainfall for the previous 12 to 24 hours and 75 percent of the maximum 6-hour rainfall (Rothacher et al. 1967). A relatively small runoff event in a 10-hectare (25-acre) watershed is shown in figure 3. The initiation of the storm hydrographs and the occurrence of peak flows closely follow the beginning and the end of rainfall.

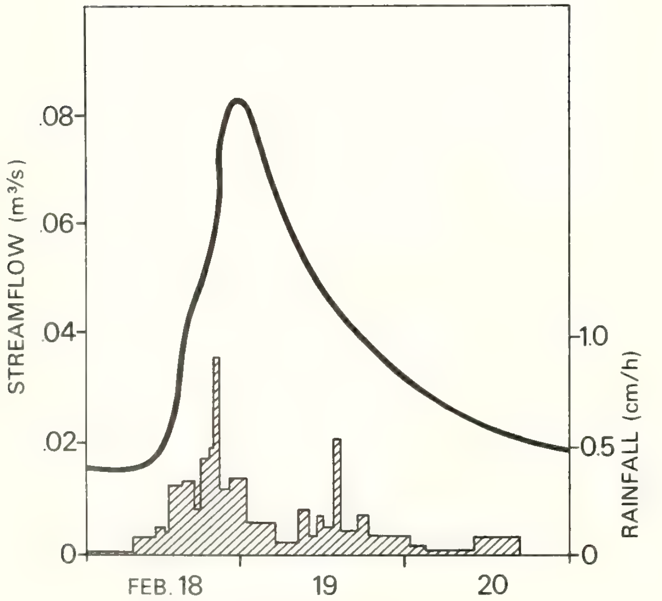

Figure 3.--Precipitation and streamflow at Watershed 10, H. J. Andrews Experimental Forest, February 18-20, 1974.

How small streams respond quickly to rainfall without overland flow is not completely understood. Perhaps the best explanation available today is what Hewlett and Hibbert (1967) have termed "translatory flow" or flow by displacement. In this process, two types of flow are distinguished although they are not entirely separable. If a line is extended from the point of initiation of a storm hydrograph until it intersects the falling limb of the storm hydrograph (fig. 4), the flow above the line becomes, by definition, quick flow and consists of channel interception and subsurface flow. The flow below the separation line is denoted delayed flow. The relative amount of quick flow is a measure of a watershed's efficiency in producing streamflow.

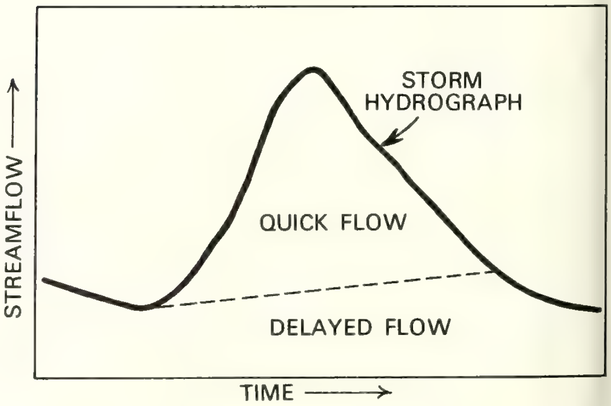

Figure 4.--Method of separating quick flow and delayed flow.

Rainfall on a slope will contribute to quick flow and delayed flow. Quick flow is composed of new rain and old rain from water stored in the soil and displaced by new rain. The wetter the soil, the greater the contribution of stored water to streamflow. Rainfall on that portion of a slope closest to a stream produces more quick flow than rainfall on a higher slope position because soil moisture content usually is greater in soil adjacent to streams due to continual drainage of soil water from upslope. Thus, these lower slopes are more conducive to translatory flow.

Understanding this theoretical process of flow by displacement may be aided by examining the analogy of water movement through a garden hose which contains some water. The three faucets in figure 5 represent different slope positions, and the length of hose attached to each represents soil of uniform texture. Water in the hoses is analogous to soil water storage with different levels of water representing different soil moisture contents among slope positions. The dashed line represents the level of soil moisture necessary for substantial translatory flow. Once the water level in a hose reaches this level, the contribution from a slope position to outflow from the sloping hose will be greatly increased.

Rainfall on the slope would be simulated by simultaneously turning on all faucets. It should be evident that water will flow almost immediately from the sloping hose (start of storm runoff), but that this flowing water will not be coming from any of the faucets (new rain). Rather it will be water that had been stored in the lower portion of the sloping hose (soil moisture storage) and was displaced by water from the lowermost faucet (new rain). It should also be evident that water from the lowermost faucet (lower slope) will reach the host outlet (stream) first, followed by that from the middle faucet (middle slope) and finally by that from the upslope faucet. The more water in

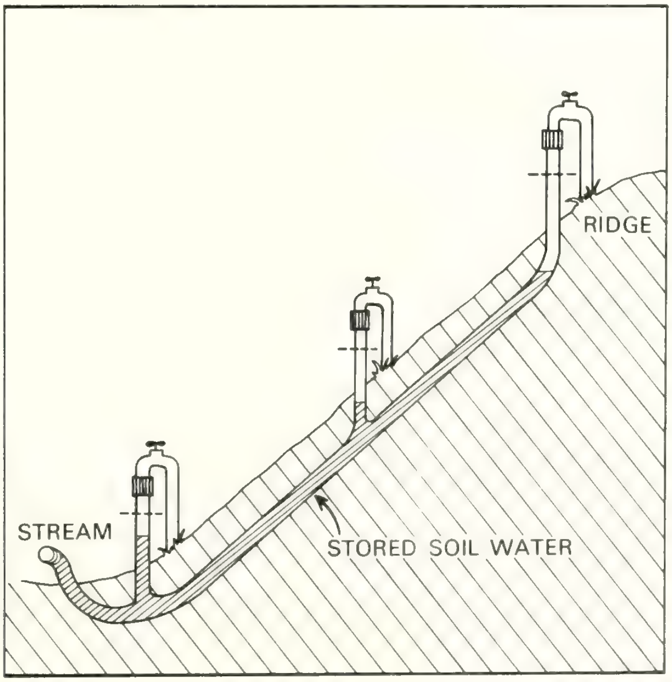

Figure 5.--Stored soil water on a slope represented by water and garden hoses. Turning on faucets simultaneously represents rain falling on the slope.

the hose (the wetter the soil at a certain slope position), the more likely it will be for a certain faucet to contribute to hose outflow (streamflow). For the upslope faucet to contribute to outflow, it must be left on (rainfall must continue) for a period of time sufficient for water from it to fill its hose to the dashed line (increased soil moisture content) so that this water can also contribute to the displacement process.

Two studies in western Oregon tend to to support this displacement theory of rapid response of small, upland watersheds to precipitation (Yee 1975, Harr 1977). In both studies, soil moisture contents remained quite high between storms. (In terms of the garden hose analogy, hoses remained nearly full.) These high moisture contents allowed the soils to respond quickly to subsequent storms; and even 1 meter below the soil surface, soil water movement increased greatly during rainfall.

VARIABLE SOURCE AREA

Perhaps the most important concept in the hydrology of small streams is the variable source area of storm runoff. This concept relates storm runoff to a dynamic source area that expands and contracts according to rainfall characteristics and the capability of the soil mantle to store and transmit water (Hewlett and Nutter 1970). In this way, a channel network grows to many times its perennial dimensions (fig. 6) and streams become both longer and wider. A smaller degree of growth is also exhibited over the course of individual storm events. This degree of change during winter storms is best illustrated by the bottom two watershed conditions in figure 6.

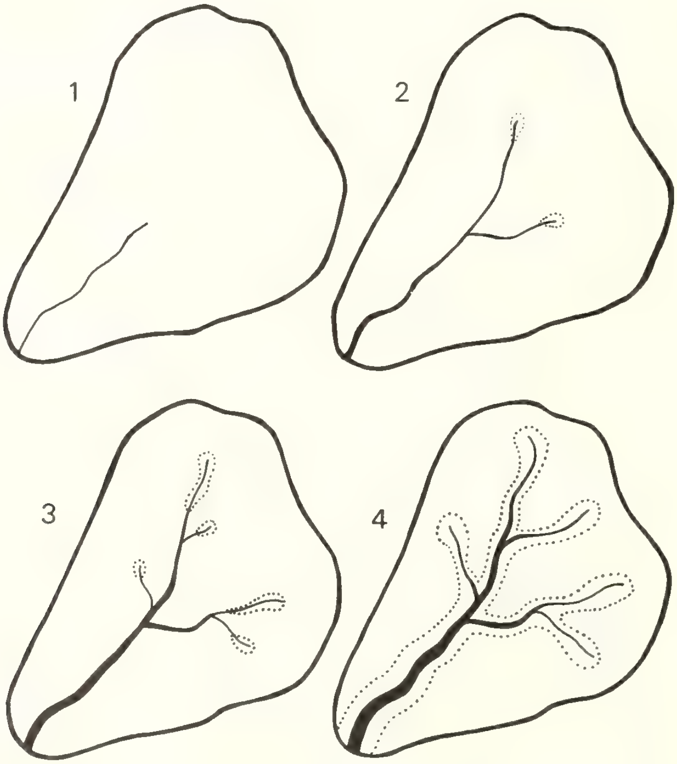

Figure 6.--Time-lapse view of a small watershed showing the expansion of the channel network and source area of storm runoff (dotted lines).

The variable source area concept has been supported by numerous hydrologic studies primarily in the eastern United States (Hewlett 1974). This concept is also consistent with field observations made in the Pacific Northwest during storm runoff periods.

As a result of the variable source area of streamflow, both quantity and quality of streamflow can change drastically over a given period of time because the proportion of a watershed actively involved in streamflow production changes. In terms of organic debris, the stream represents a depository of variable surface area as well as a mode of transportation. During extreme runoff events, debris not falling directly into the channel of the permanent stream may be subject to transport as the channel system expands. Consequently, channel expansion has important implications for proper disposal of logging debris and for application of fertilizer and pesticides. Unless one is aware of the variable source area of streamflow and its associated channel expansion, it is difficult to determine what the length and width of stream channels will be during winter high flows by simply looking at them during summer low flows. It is even more hazardous to rely solely on maps to determine stream length, because most maps are very inaccurate in their delineation of the channels of small streams. Thus, on-the-ground experience during storm runoff periods is essential to appreciate the dynamic nature of drainage networks.

PEAK FLOW

As the watershed responds to storm rainfall, streamflow increases to a maximum level known as "peak flow." Each storm hydrograph has its own peak flow reflecting the interaction of rainfall with the physical characteristics of the watershed. Higher sustained rates of rainfall contribute to greater storm runoff and higher peak flow. The magnitude of the increase in streamflow between the start of storm runoff and the peak is highly variable. It depends on both the antecedent moisture content of the watershed's soils (how much water is in the garden hose) and the characteristics of the storm. Increases in streamflow of at least two orders of magnitude are not infrequent between the start and the peak of storm runoff. Many such peak flows occur each year with substantial variation among size of peaks in 1 year as well as among years. Maximum peak flows have resulted from rain-on-snow events during which a substantial portion of streamflow comes from rapid snowmelt concurrent with the downslope flow of rainwater we have been discussing.

Some understanding of the frequency of occurrence of various sized peak flows is helpful to those dealing with small streams. Frequency information is obtained through analysis of peak flow data. The results of one such analysis is shown in figure 7 where magnitude of peak flow is plotted over return period. Return period (T_r) is given by

$$T_r = \frac{n + 1}{m};$$

where, n = years of record and m = ranking number of a peak flow among other peak flows (Linsley et al. 1958). The resulting frequency curve may be used to estimate either the magnitude of a peak flow with a certain return period or the return period of a peak flow with a certain magnitude. For example, the magnitude of a peak flow expected to occur on the average once in 10 years would be about 1.37 m^3/sec-km^2 (125 ft^3/sec-mi^2). Larger peak flows occur less frequently.

The magnitude of peak flow is inversely related to frequency of occurrence (figure 8). As magnitude of peak flow increases, the number of peaks exceeding the magnitude decreases. About 95 percent of peak flows larger than the base value of 0.11m^3/sec-km^2 (10 ft^3/sec-mi^2) are

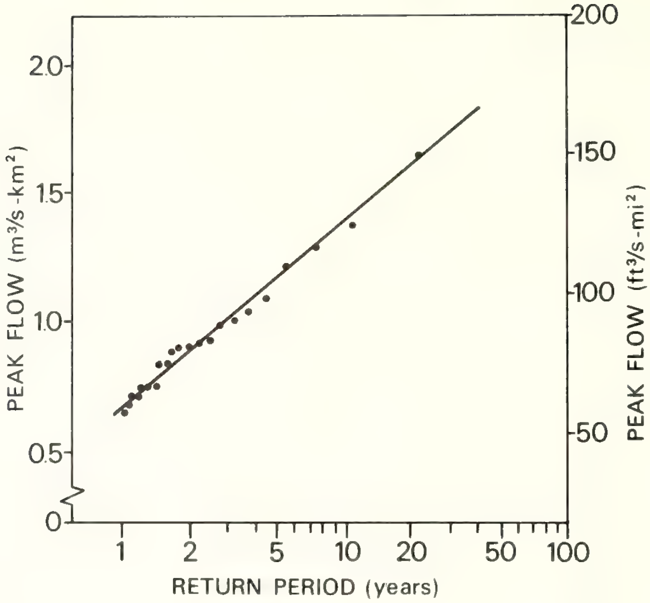

Figure 7.--Frequency curve for storm peak flows at Watershed 2, H. J. Andrews Experimental Forest, 1953-73.

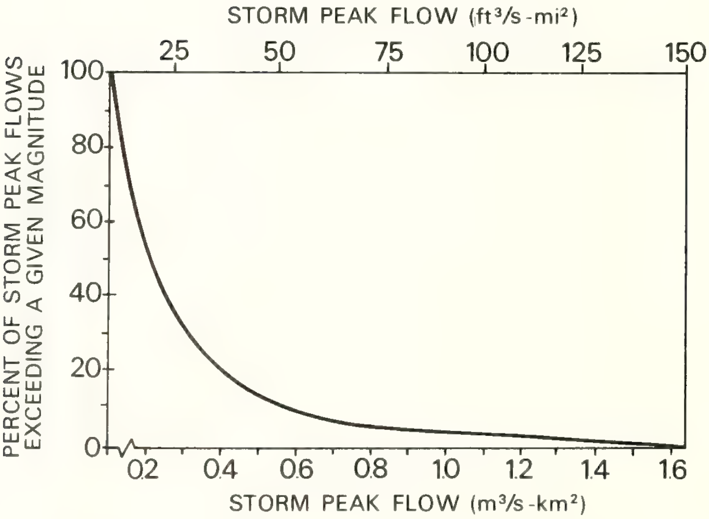

Figure 8.--Size distribution of storm peak flows greater than 0.11 $m^3/s\text{-}km^2$ at Watershed 2, H. J. Andrews Experimental Forest, 1953-73.

smaller than the average annual peak flow as estimated above. Thus, the vast majority of peak flows occurring in a small stream are relatively small. The largest peak flow shown in figure 7 resulted from rapid snowmelt during prolonged rainfall and has a return period of about 25 years. This event, which occurred in December, 1964, is estimated to have had a return period of 50 to 100 years on larger streams having a longer period of record (Rothacher and Glazebrook 1968). Although a minor rainfall-snowmelt runoff event may occur once in 2 years, the heavy rain on a deep snowpack occurs only rarely.

MINIMUM FLOWS

The distribution of annual streamflow for most small watersheds in western Oregon closely follows the distribution of annual precipitation (fig. 9). Maximum monthly flows occur during the winter months when storms are frequent and relatively large. Streamflow gradually decreases throughout the growing season as sloping soil masses slowly drain and soil water is withdrawn and transpired by plants. Minimum streamflow in perennial streams usually occurs in late summer to early fall. Minimum flow rates may be 1,000 to 5,000 times smaller than maximum peak flows that occur during winter months. Flow may cease entirely in many first-order streams. Extreme variation in flow rates has important implications for channel hydraulics which in turn influence sediment transport and the disposal of organic debris.

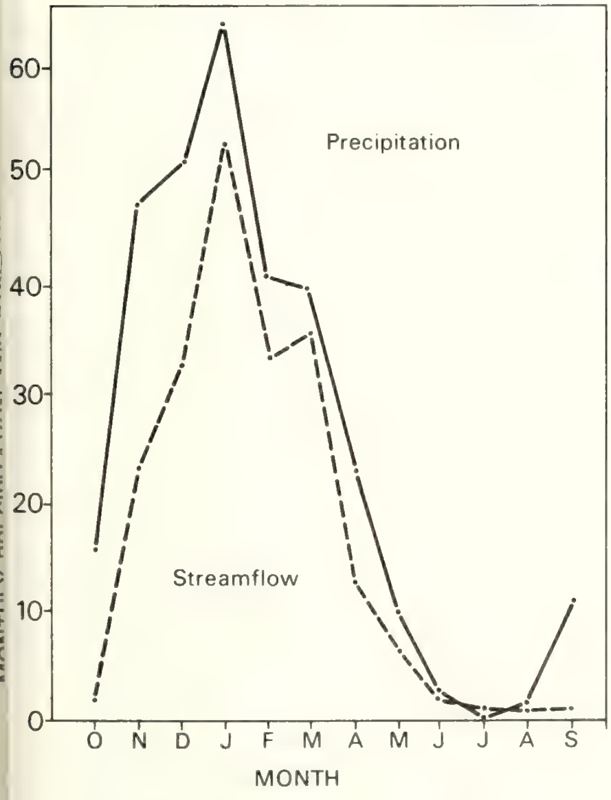

Figure 9.--Monthly precipitation and streamflow at Watershed 2, H. J. Andrews Experimental Forest for 1972 water year.

Channel Hydraulics

So far this discussion has been restricted to routing water from the watershed slopes to the stream. We have seen that both channel length and width increase markedly over time according to the nature of the interaction among certain hydrologic processes. This section examines the water in a stream channel and shows how its movement through the channel is related to certain characteristics of the channel, that is its gradient, width, depth, and velocity of flow. (The width discussed in terms of expansion of channel networks referred to distance across a stream at a fixed point. This width generally increases and decreases over a water year or during storm runoff. The width to be described in this section refers to the variation in distance across a stream from one channel segment to the next.)

Two basic relationships are involved in water movement through a channel system. First, gravitational and frictional forces affect streamflow. Gravitational forces cause water movement and frictional forces resist flow. The gravitational component depends on the inclination of the channel bed; the steeper the channel gradient, the greater the gravitational component and the greater the tendency for water to flow.

The frictional forces depend on the nature of the bed and banks, i.e., size and shape of bed materials, presence of brush along banks, etc.

The second relationship is between the rate of streamflow or discharge and the hydraulic characteristics, namely, channel depth and width and streamflow velocity. Discharge Q at a fixed point may be expressed as

$$Q = WDV$$

where W = width, D = depth, and V = average velocity of water past a point. From this equation, you can see that for any constant discharge Q, a change in one characteristic on the right-hand side of the equation must be accompanied by a change in at least one other characteristic. For example, if width W doubles from one channel segment to another immediately downstream, depth D, velocity V or both must be decreased such that Q remains constant.

Within a particular drainage network, average channel gradient is inversely related to stream order number. Thus, the small streams we are dealing with are characterized by relatively steep gradients. These gradients are, however, averages; and there is usually considerable deviation from them over the length of a channel. Many streams exhibit a pool-riffle type of appearance in which relatively deep, low-gradient, slow-moving pool segments are separated by relatively shallow, high-gradient, high velocity riffle segments. Such pools and riffles appear to depend on some degree of heterogeneity of bed material size (Leopold et al. 1964) or heterogeneity in resistance of channel bedrock to abrasion. Pools tend to form behind coarser bed materials or behind ridges of rock more resistant to abrasion. In some instances, pools may also form behind logs or accumulations of other organic debris (Heede 1972).

Flowing water possesses considerable kinetic energy directly proportional to the square of flow velocity. As velocity increases with an increase in streamflow or channel gradient, energy of flowing water in a uniform channel, that is, one with no change relative to distance in gradient, depth, or width, will also increase. Energy is dissipated by the resistance between the stream and its bed and banks; by internal resistances caused by boundary features such as bends, bed topography, junctures, etc. that set up eddies and secondary circulations; and by spill resistance caused by water flowing rapidly over an obstruction into flow of much lower velocity. In many small streams, logs and other large organic debris serve as energy dissipators by acting as flow deflectors and as dams over which water must flow. The kinetic energy of flowing water increases and decreases with velocity in a downstream direction as the gradient constantly changes and as water flows through a pool-riffle series of which large organic debris may be an integral part.

Seasonality of Runoff Processes

The seasonality of runoff production may be summarized by describing the sequence of streamflow conditions for a small watershed. This watershed is drained by a permanent, second order stream.

In late summer prior to the fall rains, soil moisture levels are at their lowest because water has been removed by evapotranspiration and slow drainage to streams. Storms are infrequent and small and a large proportion of rainfall, when it does occur, is intercepted by forest vegetation and evaporated with little water reaching the soil. Any storm runoff during this period results almost entirely from channel interception, and peak flows are extremely small. Consequently, the stream has little capacity to move sediment or transport more than small, floatable debris. Streamflow is maintained by slow drainage from soil into isolated saturated zones from which water seeps slowly into the adjacent stream. Streamflow is at a very low rate, and stream network dimensions are at annual minimums. Most first order channels have no flow, and those containing water are short with their flow occupying only a small part of their widths. Flow may consist of a slow trickle between relatively isolated pools.

With the advent of fall rains, the forest hydrologic system becomes more active. Interception losses become proportionally smaller as storms become larger and more frequent. Gradually, rain falling on the moist lower slopes is translated to streamflow to supplement channel interception. As rains continue, soil moisture levels increase upslope, and the stream channel network begins to expand. Because soil becomes wetter and more conducive to translatory flow and because the stream channel network has tapped more of the watershed's slopes, an increasingly greater proportion of each succeeding storm is translated into stormflow. Peak flows have also increased.

By late fall or early winter, the runoff production system is near maximum efficiency. Soils have been recharged, and they remain wet between storms. A large proportion of rain falling on the entire watershed is translated into storm runoff. During the larger storms, the extent of the drainage network is at a maximum. Main channels have extended into the more remote parts of the watershed, and even intermittent channels now carry water. Soil water storage in the slopes feeding these intermittent streams, however, is insufficient to maintain streamflow between storms, and the channel network shrinks back to the channel segments which flow continually in the winter. During most winter storms, interception by vegetation is of little consequence. Transpiration rates during the winter are also quite low. Generally, decreases in soil moisture result from drainage of soil between storms. Peak flows are relatively large, and the stream is capable of moving large amounts of debris.

By early spring, evapotranspiration losses become more important and, in terms of runoff production, the watershed becomes less efficient. Storms gradually become smaller and less frequent. Forest vegetation begins to withdraw soil water such that increasing amounts of water are required to recharge the soil water reservoir. Consequently, the portion of the watershed contributing to storm flow contracts toward stream channels. In cases where soil water storage is insufficient to maintain streamflow, flow ceases altogether, and the watershed's drainage network contracts.

Finally, as summer comes, the efficiency of the watershed's runoff production decreases still further. Storms are small, relatively infrequent and interception losses are high. Translatory flow becomes less prevalent, and storm runoff results largely from channel interception. Drainage of soil and subsoil to stream channels continues but at a steadily decreasing rate. Transpiration by forest vegetation reaches a maximum, also decreasing soil water storage. Stream channels shorten until the drainage network is at an annual minumum size.

Effects of Management Activities

Watershed studies in western Oregon have evaluated the effects of timber harvesting activities on streamflow. A brief review of these effects on various aspects of streamflow follows.

ANNUAL STREAMFLOW

Increases in the amount of water flowing from a watershed after cutting forest vegetation has been shown many times in many places (Hibbert 1967). In western Oregon, such increases are near the maximum observed. For example, after extensively clearcutting a small watershed in the Oregon Coast Ranges, annual streamflow increased 60 cm (24 in) (Harris 1973). Similarly, clearcutting an entire watershed in the western Cascade Range increased annual streamflow 46 cm (18 in) (Rothacher 1970). Watersheds less extensively cut showed smaller increases. In terms of the hydrologic system described in this report, removal of forest vegetation drastically reduces interception and transpiration losses such that more soil water drains into streams. As vegetation returns, however, such increases in annual streamflow decrease as both interception and transpiration increase.

MINIMUM FLOWS

Removal of forest vegetation considerably increases streamflow during the summer low flow period. Although absolute increases are small, relative increases are large. For example, minimum flows were tripled after a small watershed in the western Cascade Range was clearcut and burned (Rothacher 1971). Similar increases in low flow were observed in the Coast Ranges (Harr and Krygier 1972). Again, such increases result from drastically reduced transpiration making more soil water available for streamflow. Such increases are relatively short-lived as revegetation occurs.

PEAK FLOWS

Removal of forest vegetation increases average peak flows. Greatest increases have been noted for fall peaks (Rothacher 1973, Harr et al. 1975). Such increases have resulted primarily from changes in soil moisture contents on areas where trees are cut. When forest vegetation is removed, soil moisture contents remain higher than on a forested area so that less fall rain is required to recharge soil moisture, and more rainfall can be translated into streamflow. By winter, however, when soil moisture in a cut area has been recharged, the cut area responds nearly the same hydrologically as it did before its trees were removed. Interception is less after trees are removed; but as we saw previously, interception during larger winter storms is minimal. Thus, timber removal has little effect on the size of large peak flows (Rothacher 1971 and 1973, Harris 1973, Harr et al. 1975).

Soil disturbance, on the other hand, may have a pronounced effect on the size of even large peak flows. For example, road surfaces have virtually no infiltration capacity, and road cuts may intercept slow subsurface flow and rapidly transport water through a ditch-culvert system. As a result, peak flows for small, headwater streams may be increased when roads occupy at least 12 percent of a watershed (Harr et al. 1975). There is some indication that severe soil disturbance resulting from tractor skidding and windrowing slash may also increase larger peak flows (Harr 1976).

CHANNEL HYDRAULICS

Certain forest activities may indirectly affect channel hydraulics of small streams by accelerating the occurrence of soil mass movements, a major form of natural erosion in western Oregon as well as in other areas of extremely steep topography. For example, most soil mass movements in the H. J. Andrews Experimental Forest have been associated with roads (Dyrness 1967). Roads were also the major source of sediment in study in the Coast Ranges (Brown and Krygier 1971). Clearcutting on steep slopes with shallow, residual soils can also increase the frequency of occurrence of soil mass movements (Swanston 1974). Large amounts of soil, rock, and organic debris frequently are deposited in small streams. Channel hydraulics are seriously altered not only by this deposition, but also by the sudden release of water and debris when a dam formed by such deposition fails and a stream channel is scoured to bedrock (Fredriksen 1970).

Channel hydraulics may be adversely affected by removal of naturally occurring large organic debris. In many instances, such debris may have become part of a stable stream environment and, as stated previously, serves as dissipator of a stream's kinetic energy. After such naturally occurring debris is removed in stream cleanup, during or after timber harvest, severe erosion of stream banks and beds may occur. Where debris is keyed into banks, removal may reduce lateral support of soil masses and expose soil to flowing water. Kinetic energy, formerly dissipated by water flowing over debris dams, may be used to erode stream banks and move bed material.

Summary

1. Subsurface flow of water through the soil mantle is the primary mechanism by which water is transmitted from the soil surface to streams. Overland flow rarely occurs because infiltration capacity of undisturbed forest soils is rarely limiting.
2. A watershed's channel system expands and shrinks according to the interaction between rainfall characteristics and the ability of the soil mantle to transmit water. Consequently, a drainage network is much larger during winter storms than during late summer.
3. Flow rates vary considerably. Peak flows in winter may be 1,000 to 5,000 times greater than summer low flows. Peak flow during winter storms may be 100 times greater than flow before storms. The larger a peak flow, the less its frequency of occurrence.
4. Channel hydraulic characteristics vary greatly over time and space due to heterogeneity of bed materials and to the accumulations of large organic debris.
5. Annual streamflow, summer flow, and small peak flows (notably those in the fall) may be increased after clearcut logging. Large peaks are not affected by forest cutting but may be increased when seriously compacted soil occupies at least 12 percent of the watershed.
6. Both clearcutting and roadbuilding may cause soil mass movements in some areas. Such mass movements, as well as those occurring naturally, may drastically change the channel hydraulics of small streams by damming or scouring them.
7. Large organic debris may be part of a stable channel. Removal of such naturally occurring debris during stream cleanup after timber harvest may accelerate erosion of stream banks and channels.

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HISTORY, PHYSICAL EFFECTS, AND MANAGEMENT IMPLICATIONS of Large Organic Debris in Western Oregon Streams

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Abstract

Large organic debris has historically been an important element in small mountain streams of the Pacific Northwest. The debris serves to slow the movement of water and inorganic and fine organic matter through the channel. Debris may remain in the channel for decades or longer, and tends to stabilize some sections of a streambed and streambanks while destabilizing other areas. The combination of clearcutting and the complete removal of large debris in a channel may deprive a stream of this natural feature of streams for a century or longer. The consequences are likely to be downcutting and "channelization" of the stream, accelerated transport of fine organic and inorganic sediment, and a possible decrease in biological productivity of the stream ecosystem. Therefore, stream debris management during logging operations should include leaving undisturbed the natural, stable organic debris in the channel.

The principal factors controlling the concentration, stability, and functions of stream debris are the history and condition of the surrounding timber stand, flushing history of the channel, stability and abundance of bedload material, steepness of the channel and adjacent hillslopes, and slope stability in the drainage. Because of this complexity, each stream presents a unique situation which should be inspected in the field and considered on an individual basis before a debris management decision is made.

KEYWORDS: Stream environment -)debris, mass movement, residue, western Oregon.

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TABLE OF METRIC CONVERSIONS

1 foot = 0.305 meter

1 yard = 0.914 meter

1 ton = 1.016 tonne

1 ton/100 foot of channel = 3.331 tonne/100 meter

1 acre = 0.405 hectare

1 event/mile^2 = 0.386 event/kilometer^2

1 yard^3 = 0.764 meter^3

Introduction

Determining optimum amounts of large debris in streams is difficult. The situation is complicated by the complexity and variability of the stream environment and the variety of ways resource managers view stream debris. Fisheries biologists, stream ecologists, water quality experts, and road design and maintenance personnel would all probably set different standards for stream debris concentrations. Much of the present indecisiveness about management of stream debris may stem from lack of understanding of the biological and physical functioning of debris in small mountain streams. The theme of this paper is that streams and their biota developed through a long history of high concentrations of debris and that perhaps a closer look at the history of natural debris in stream environments will help in managing these streams in the future.

The following comments are the result of a reconnaissance study of large debris in streams which is being carried out by the authors along with hydrologist R. L. Beschta (Oregon State University). We are attempting to assess the origins and history and biological, hydrologic and geomorphic impacts of stream debris in both undisturbed and man-influenced streams in western Oregon. The results of this work are still in a preliminary form.

Background

The streams of western Oregon and Washington are commonly littered with tree tops, limbs, root wads, and whole trees (fig. 1). Debris greatly

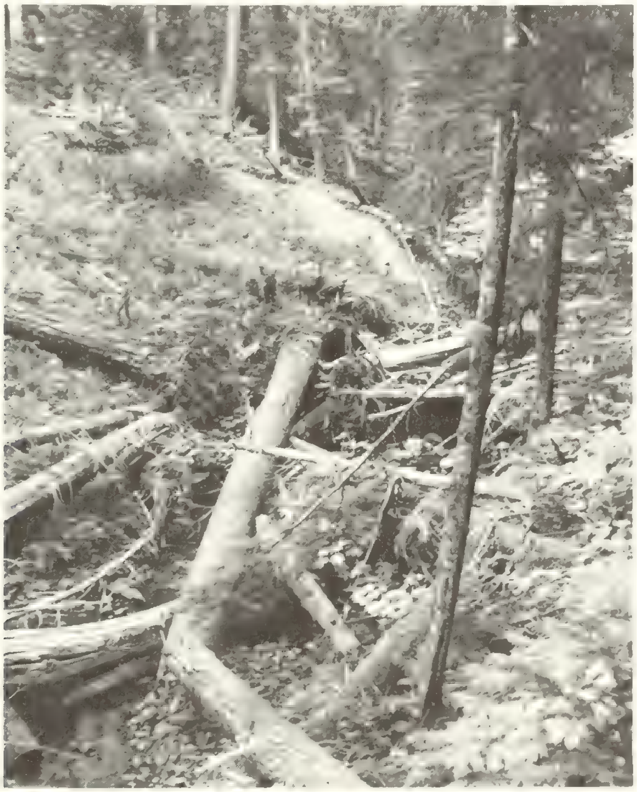

Figure 1.--Large organic debris in Lookout Creek, H. J. Andrews Experimental Forest. Note figure in left center of picture.

influences stream biology, hydrology, and sediment transport. Therefore, it is surprising how little study there has been of the origin, fate, and consequence of large organic debris in streams.

The only published work on quantities of organic matter in Pacific Northwest streams is that of H. A. Froehlich and his students (Froehlich 1971; Froehlich, McGreer, and Sedell 1972; Lammel 1972; Froehlich 1973). Their studies have been designed to assess volume and weight of coarse and fine debris in streams flowing through various types of stands. They sampled streams before and after falling and after yarding in units harvested with various logging systems and stream protection procedures. The measured quantities of organic debris in undisturbed streams were both very large and extremely variable. Measured concentrations range from 0.9 ton up to 26 tons/100 ft of channel. They also observed that, following logging, the volume of debris in the streams had been modified to levels ranging between 60 and 360 percent of prelogging debris concentrations, depending on the management procedures used.

The biological consequences of large debris have been reviewed by Narver (1971), Brown (1974), Hall and Baker (1975), Triska and Sedell (1975), and others. Excessive large debris may form jams which block fish passage, cause spawning areas to be flooded with gravel, and increase streambank cutting. Movement of debris may shift gravel, possibly destroying eggs and alevins. Large debris also has beneficial functions in the stream environment. In many situations large debris tends to stabilize the streambed and banks. The presence of stable debris slows the routing of fine organic matter through the stream, allowing greater opportunity for biological processing of fine organic detritus. Bustard and Narver (1975) also cite the importance of logs and roots as overwinter cover sources for salmon and warn against "overzealous stream cleaning."

Geomorphic consequences of large debris in streams have been studied even less than the biological effects. In small New England streams, Zimmerman et al. (1967) observed that channel width in forested stream sections tended to be wider and more variable than streams cut through sod covered banks. Forest vegetation may have a variable effect on the stability of the banks and bed. Stability is enhanced and the channel is narrowed where root systems extend through the banks and channel bottom. The channel may also be destabilized and widened above debris dams and where trees are tipped over. In drainages larger than several square miles, stream width is more uniform than in smaller basins. Zimmerman and others believe that in small streams living and dead vegetation is important in shaping channel geometry, but this influence drops off sharply in larger streams where hydraulic capabilities of the stream become dominant.

Several unpublished USDA Forest Service reports and Colman (1973) note that large debris in streams tends to destabilize the streambed and banks. This is particularly common in gravel-rich streams where natural and man-caused hillslope instability has accelerated sediment supply to the channel. In these settings, large organic debris may slow sediment transport, cause braiding or meandering of the channel over its widened bed and lead to stream bank cutting. Increased bank erosion aggravates the stream problems by introducing more sediment to the channel and possibly causing more extensive instability of adjacent hillslopes.

Although the biologic and geomorphic consequences of debris in streams cannot yet be quantified in terms of fisheries productivity, sediment yield, or other impacts, there does seem to be a growing recognition of the importance of large organic debris in the stream environment. Past recommendations for stream debris management state a need to maintain moderate, premanagement levels of large stream debris (Heede 1972a, b; Brown 1974; Bustard and Narver 1975; and others).

Movement of Large Organic Debris Into Streams

Large organic debris enters the the stream channel by a variety of mechanisms. Several of the mechanisms are interrelated, allowing debris to enter the stream by a chain reaction of events.

A high percentage of stream debris is comprised of tree tops, large limbs, and whole trees blown into streams by strong winds. These pieces may land directly in the creek or on the adjacent hillslopes and then slide into the creek. Therefore, streams in narrow, steep walled valleys may tend to receive more large debris than streams flowing through similar timber stands on broad, flat flood plains.

Undercutting of streambanks may also cause trees to tip into the channel. This process is particularly effective in getting massive, stable root wads and tree trunks into streams. In western Oregon this process is most important on the larger streams which can rework their flood plain. The small first-, second-, and third-order channels are commonly cut on bedrock so the streams have limited ability for lateral cutting. (Stream order is defined by Harr (1976) and Leopold, Wolman, and Miller, 1964).

In a variety of ways the slow encroachment of deep-seated slumps and earthflows on stream channels leads to heavy loading of limited reaches of channel (up to hundreds of yards) with both large organic debris and inorganic sediment (Swanson and James 1975). Earthflow movement tips trees, making them highly sensitive to windthrow. Earthflows also constrict a stream channel until a high discharge event undermines the toe of the earthflow and the opposite streambank, causing a series of small slumps and slides which carry organic matter, including whole trees, into the channel. The continued closing of the channel and instability of the streambanks result in the formation of high stacks of loosely structured debris.

Debris slides and avalanches from adjacent hillslopes, but well above the influence of any streambank cutting, also introduce large organic matter to stream channels. As discussed in the following section, these events commonly result in debris torrents, or "sluice outs", which pick up organic and inorganic material along the channel as they move rapidly downstream.

It is often difficult to pin-point a single mechanism as the means by which an individual piece of large debris has entered the channel. For example, at the toe of an earthflow, the combined forces of bankcutting, windthrow, and deep-seated earth movement may work together--the earthflow tipping the tree and aiding streambank erosion, both of which render the tree highly susceptible to blowdown.

Movement of Large Organic Debris Along Streams

Large pieces of organic debris are moved through a stream system by a variety of mechanisms ranging from episodic flushing during extreme flood events to the everyday release of dissolved or finely divided material as a result of decomposition and physical breakdown by wood processing invertebrates. In many cases, streams bypass debris accumulations, leaving the debris buried in the flood plain to decompose for long periods until the stream cuts back to rework the deposit. These slow, persistent processes of debris decay and breakup are probably dominant mechanisms of movement of large organic debris out of many western Oregon streams. It is the violent flushing events, however, which present the greatest concern to land managers. Flushing occurs either by flotation during high water or by transport in debris torrents as large volumes of organic debris, soil, rocks, and water are "sluiced out" of channels.

The ability of a stream or river to float large debris depends on both the size of the free-flowing part of the water course and the size of debris. In large rivers such as the main branch of the McKenzie, nearly any piece of organic material that enters the river can be floated and transported downriver. Of course, smaller streams can float only small debris. Floated debris, especially in small streams, usually does not travel far before it is stranded on streambanks at high flow levels or against obstructions in the channel. Culverts and stream crossings are particularly troublesome obstructions which may sustain heavy damage from floated debris and associated drainage problems (Rothacher 1959; Rothacher and Glazebrook 1968).

Very large debris can be transported through small channels only in debris torrents such as those described by Fredriksen (1963, 1965). Such highly destructive events are of great concern to land managers. Torrents damage roads, denude significant areas of timber growing land, and severely disturb the stream environment.

Debris torrents may be triggered by the breakup of debris jams in a channel, the collapse of a road fill in a channel way, or a slide entering the channel from the adjacent hillslope. Slides and debris avalanches from hillslopes may trigger debris torrents in several ways. Slide debris may enter the channel and temporarily block it, backing up a small lake until the dam is saturated or undercut, releasing a surge of debris down the channel. In many cases slide debris probably moves directly down the channel, maintaining the momentum picked up coming down the steep slope at the side or head of the stream.

Regardless of the triggering mechanism, once a debris torrent has begun, it moves rapidly down channel, entraining sediment and debris in the channel and soil, organic detritus, and living vegetation from adjacent hillslopes as it scours the streambed and banks. Decreasing stream gradient and channel obstructions, including heavy stands of timber, eventually stop the torrent and create an area of deposition. Such torrents are rare in channels larger than second- or third-order because a steep channel gradient is needed to maintain the momentum of the churning mass of debris.

Torrents commonly scour up to 20 feet on the streambanks, exposing bare soil which is subject to surface erosion and small scale slumping and sloughing for a period of years after the initial event. This material is eventually moved downstream as bedload and collects behind the sediment and debris deposited by the torrent. In low gradient settings the organic matter in the jam acts as a regulating valve, rotting over the course of one to two centuries and slowly releasing the stored mineral sediment to downstream areas.

To develop a feeling for the frequency and significance of debris torrents, we can turn to two study sites in the Cascades. The H. J. Andrews Experimental Forest near Blue River, Oregon, has experienced at least 38 debris torrents since 1950[1]. These events scoured between 50 and 1,650 yd of stream channel each. Morrison (1975) studied 15 debris torrents which occurred in the Alder Creek drainage, a tributary to Fall Creek in the Willamette National Forest. He estimated the debris torrents in the 4,300-acre drainage scoured soil from about 17 acres of streamside hillslopes in the past 90 years. About 45 percent of this erosion was the result of management activities during the past 11 years.

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[1] Swanson, Frederick J. Unpublished data on file at the School of Forestry, Oregon State University, Corvallis.

The sites where debris torrents were initiated have been analyzed to determine land management history and whether or not slides from adjacent hillslopes appeared to have started the debris torrent (table 1). These data indicate slides from hillslopes are the dominant mechanism of initiating debris torrents, having been a contributing factor in 83 percent of the 53 torrents analyzed. The dominance of roads as slide initiation sites (Dyrness 1967; Morrison 1975; Swanson and Dyrness 1975) is reflected in the high frequency of debris torrents triggered by road-related slides (table 1). Most of the road failures that resulted in debris torrents were fill failures in steep headwall settings where organic debris had no apparent role in triggering the slide. Only nine of the torrents appear to have been initiated in stream channels in forested and clearcut areas. In these settings, mobilization of organic debris in the channels is a likely triggering mechanism for torrents. In six of these cases, slump and earthflow movement into the stream probably contributed significantly to channel instability. In one drainage where the headwaters have been clearcut and there is active deep-seated mass movement, the channel has had three debris torrents in the past 25 years. A large fan of debris at the foot of the watershed indicates debris torrents also occurred frequently before there were any management activities in the area.

Although these reconnaissance studies suggest that debris in streams is not a primary cause of debris torrents in the Cascades, debris is commonly believed to aggravate the destructiveness of torrents once they have begun. As a torrent moves down channel, it picks up debris which had previously collected in the channel. The work of Froehlich (1973) and others indicate this may amount to more than 20 tons of downed organic matter per 100 ft of stream channel. Large volumes of entrained debris, however, may cause

Table 1--*Land-use status of triggering sites of debris torrents in the H. J. Andrews Experimental Forest*[1] *and Alder Creek drainage*

Site	Percent of watershed in 1975	Period of record	Debris torrents: Triggered by hillslope slides	Debris torrents: With no identified related slide	Debris torrents: Total	Debris torrents: Per square mile per year
		Years	Number	Number	Number	Number
H. J. Andrews Experimental Forest (15,860 acres):						
Clearcut	18.7	25	5	6	11	0.10
Road	3.3	25	17	--	17	.83
Forest	78.0	25	9	1	10	.02
Total	100.0	--	31	7	38	--
Alder Creek drainage (4,300 acres):						
Clearcut	26.0	15	2	1	3	.11
Road	3.5	15	6	--	6	1.67
Forest	70.5	90	5	1	6	.01
Total	100.0	--	13	2	15	--

[1] Swanson, Frederick J. Unpublished data on file at the School of Forestry, Oregon State University, Corvallis.

a torrent to stop sooner due to increased friction among the large pieces of debris being churned along and against the adjacent valley walls and vegetation. There may be a trade off of shorter, wider torrent tracks down debris filled channels in comparison with longer, narrower tracks in cleared streams. From observations in the H. J. Andrews Experimental Forest and Alder Creek Watershed, it appears destructiveness of torrents reflects the volume of slide material initially entering the stream rather than the pretorrent debris load of the channel.

Origins of Debris Accumulations

The spatial distribution of debris accumulations in streams is controlled by the stability of adjacent soils and timber, the history of debris movement down the channel, the shape of the channel, and perhaps other processes. Accumulations may form as a result of instream sorting during high streamflow. In larger streams there is greater opportunity for debris transport and sorting to take place; consequently, the debris in intermediate and large streams tends to be concentrated in distinct accumulations. Generally, organic debris in small streams is randomly distributed. Because of this scattering of debris and the large size of individual pieces relative to channel dimensions, it is seldom possible to identify individual accumulations in first- and second-order streams.

Accumulations may also originate from influences outside the channel where several large pieces of debris enter the stream in a single event. This may happen where a group of trees are blown down in "domino" fashion, where streamside or hillslope slides enter a stream, or where deposition occurs at the end of a debris torrent track.

The mode of origin of an accumulation determines its structure and function. For example, the large accumulations at the toes of earthflows tend to be high, open stacks of debris which are very inefficient at trapping sediment and diverting water movement. On the other hand, debris torrent accumulations are typified by tight networks of organic debris with the upstream portion flooded with inorganic sediment. Such a structure efficiently traps sediment transported from upstream.

Most debris accumulations are formed by a variety of interacting mechanisms operating intermittently throughout the history of the accumulation. For example, in a second- or third-order channel, an initial accumulation may be formed by several pieces of blowdown. This channel obstruction may then trap finer floated debris, further closing off the channel and deflecting the stream against the bank. The resulting erosion may undermine the bank and cause large pieces of streamside vegetation to fall into the stream. Such a historical sequence may span several decades marked by periodic shifts in the configuration of the accumulation as large storms change the stream channel and the amount of trapped sediment.

Case Studies

It is useful to examine case studies of several streams to illustrate how these generalizations about the origins, history, and consequences of pieces and accumulations of debris apply in real streams. For this reason, we have studied large organic debris in several western Oregon streams. These streams have been the subject of other biologic and geomorphic research; and they were selected to represent a variety of drainage areas, stand types and ages, management histories, and geologic and geomorphic settings. In each study area, at least 800 ft of stream channel were mapped. Here we present observations on sections of five channel reaches: clearcut and old-growth sections of an intermediate size stream, Mack Creek; an old-growth reach of a smaller stream, Zog Creek; and two unnamed streams flowing through young stands developed after wildfires 75 and 135 years ago. All streams drain areas of volcanic bedrock of the western Cascade range in land managed by the Willamette National Forest.

The study section of Mack Creek, located in the H. J. Andrews Experimental Forest near Blue River is a third-order channel which drains about 1,500 acres. The channel gradient is about 10 percent. Where streamflow is not influenced by organic debris, the bed is made-up of large boulders up to 6 ft in diameter.

Zog Creek is located 30 mi east of Eugene in the Alder Creek drainage which has recently been the subject of erosion studies by Morrison (1975). The study section drains approximately 160 acres. The mapped channel has an average gradient of about 30 percent; and where there is little influence of organic debris, it flows over a series of bedrock chutes and patches of gravel.

The unnamed streams flowing through young stands are tributaries of Blue River just north of the H. J. Andrews Experimental Forest. These boulder dominated streams drain watersheds of less than 40 acres.

Methods

In each of the study reaches the stream channel and all pieces of organic debris longer than 5 ft were mapped using a tape, range-finder, and compass. For each significant piece of debris or debris accumulation, data were collected describing the size of principal pieces of debris, its stability, origin, and degree of decomposition; the volume of trapped sediment; height of debris-influenced drop in water level; and, channel characteristics. Since most large pieces in the study area had not been transported by the stream, the origins of most pieces of debris more than 20 to 30 ft in length could be determined by careful inspection of the position of the root wad or nearby snags or topped and downed trees.

The time of emplacement of individual pieces in the Mack Creek section was estimated by dating small trees, commonly western redcedar and western hemlock, which were growing on the debris. These estimates are clearly minimum values because a period of perhaps 5 or more years may have elapsed before establishment. In some cases, it was possible to date scars on living trees damaged by the large debris falling into the channel. Where dated debris overlies other material, it was assumed that the underlying material was older than the dated log.

Results

ZOG CREEK

The 200-ft reach of Zog Creek mapped in figure 2 is typical of many small western Oregon and Washington streams flowing through a steep walled valley (average sideslopes about 90 percent) and an old-growth Douglas-fir, western redcedar, and western hemlock forest. The abundant large organic debris has a great influence on the stream--31 pieces of debris 5 or more feet in length have some influence over the movement of sediment and water through the 200-ft section. Deeply scoured pools are formed at falls or areas of convergent flow below obstructions. Approximately 32 percent of the drop of the stream is influenced by debris. The debris has trapped an estimated 25 yds of sediment in small bars and shallow pools above obstructions. All of the large debris appears to be very stable. Several trees of about 1.5-ft dbh have grown on old, rotten pieces of debris in the channel, suggesting that as the old debris was losing strength during decomposition, it was also being anchored and reinforced by the developing root system of the living tree. This also indicates that the channel has experienced no violent flushing event in the past 60 plus years.

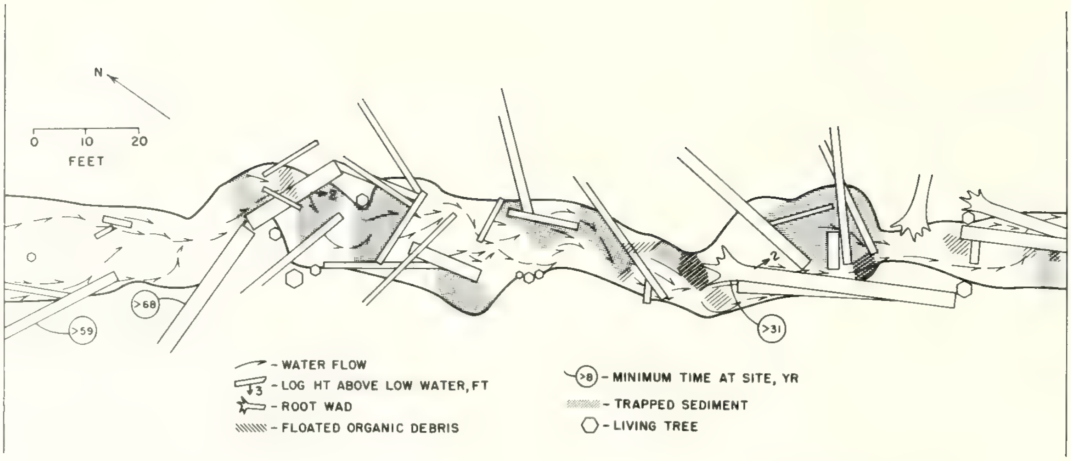

Figure 2.--Map of large organic debris and other material in a 200-ft forested section of Zog Creek.

MACK CREEK - FORESTED SECTION

Maps of two adjacent 200-ft sections of Mack Creek are shown in figures 3 and 4. This stream reach is probably representative of steep channels 20 to 30 ft in width flowing through old-growth stands in the Pacific Northwest. As in the case of Zog Creek, Mack Creek contains abundant coarse organic debris. The study area is part of a stream section in which Froehlich et al. (1972) measured 11.7 tons of large debris (greater than 4 in) per 100 ft of channel.

The large debris in the forested section of Mack Creek forms a series of distinct accumulations which play a variety of roles in the stream environment. Accumulations MA-14 and MA-18 (figs. 3 and 4) converge the flow into a scoured pool near the center of the channel; MA-13 and MA-15 deflect the stream away from one bank, forming scour pools against the far bank; MA-16 and MA-17 effectively intercept sediment and floatable fine organic matter across the entire channel and develop broad, shallow, depositional pools upstream and deeper, narrower plunge pools at the base of falls; MA-12 is mainly floated debris thrown up on the bank on the outside of a bend, thereby offering some protection from streambank undercutting. These accumulations have trapped and temporarily stabilized over 300 yd^3 of sediment. The debris also influences about 50 percent of the drop of the stream through this 400-ft reach. A variety of data on each accumulation is shown in table 2.

Most pieces of debris more than 30 ft in length have not moved since they entered the stream as windfall. Only a few trees appear to have been undercut by the stream prior to toppling into the channel. The accumulations are composed of 10 to 60 percent floated debris up to about 25 ft in length.

Minimum dates on the emplacement of major pieces of debris indicate they have had surprisingly long histories of stability in the channel (table 2 and figures 3 and 4). Five of the seven accumulations originated more than 20 years ago, and MA-13 appears to be in part more than 100 years old. This indicates that flushing of major pieces of debris through this channel has not occurred in the past century.

In the mapped stream reach, organic debris has greatly modified gross

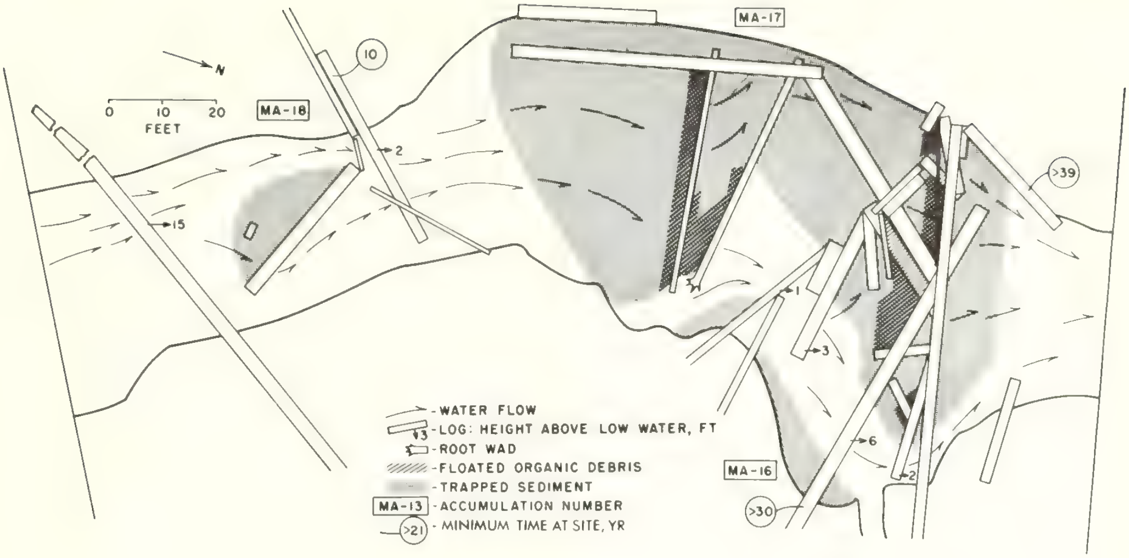

Figure 3.--Map of large organic debris and other material in a 200-ft forested section of Mack Creek immediately upstream from the section in figure 4.

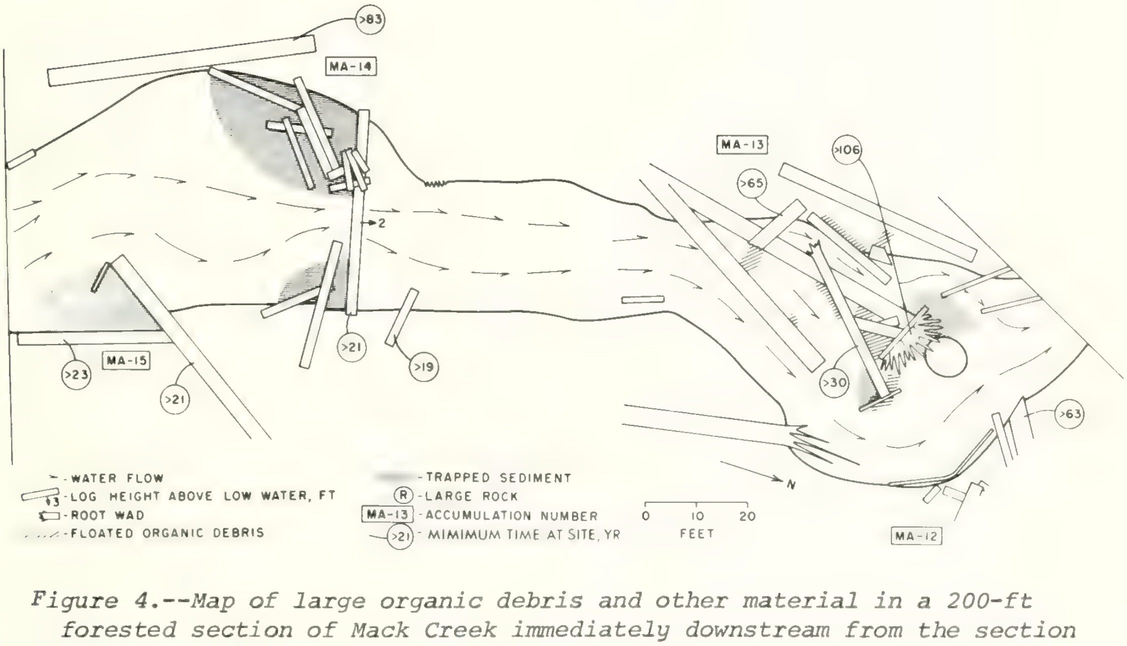

Figure 4.--Map of large organic debris and other material in a 200-ft forested section of Mack Creek immediately downstream from the section shown in figure 3.

Table 2--*Data on debris accumulations in 400-foot section of forested Mack Creek. Shown in figures 3 and 4. Ages were determined in 1975.*

Debris accumulation	Debris influenced stream drop	Trapped sediment	Channel width affected	Floated debris	Age of core of accumulation
	Feet	Cubic years	Percent	Percent	Years
MA-12	0	15	30	60	63+
MA-13	3	45	60	10	108+
MA-14	0	40	100	50	21+
MA-15	0	5	30	10	21+
MA-16	8	120	100	25	30+
MA-17	5	50	75	50	11+
MA-18	4	30	80	40	9 to 10
	20	305			

channel morphology in two cases. Accumulations MA-16 and MA-17 have caused a pronounced widening of the channel by developing overflow channels along the east bank. The history of MA-13 began over 100 years ago when the central piece of the accumulation, a massive western redcedar, fell diagonally up the channel, perhaps as a result of streambank cutting. As other organic debris collected against this obstruction, the channel was more effectively diverted into the eroding streambank; so now most of the streamflow goes around the accumulation.

MACK CREEK - CLEARCUT SECTION

A 200-ft section of the clearcut portion of Mack Creek is shown in figure 5. The area was cut but not yarded before the winter of 1964-65. Extremely high stream flows during winter moved logs, slash, and roots downstream and lodged them behind a massive, pre-existing debris jam in a stand of old growth at the base of the unit. Froehlich et al. (1972) found the clearcut section contains only about 4 percent of the large debris observed in the forested section immediately upstream. They also found

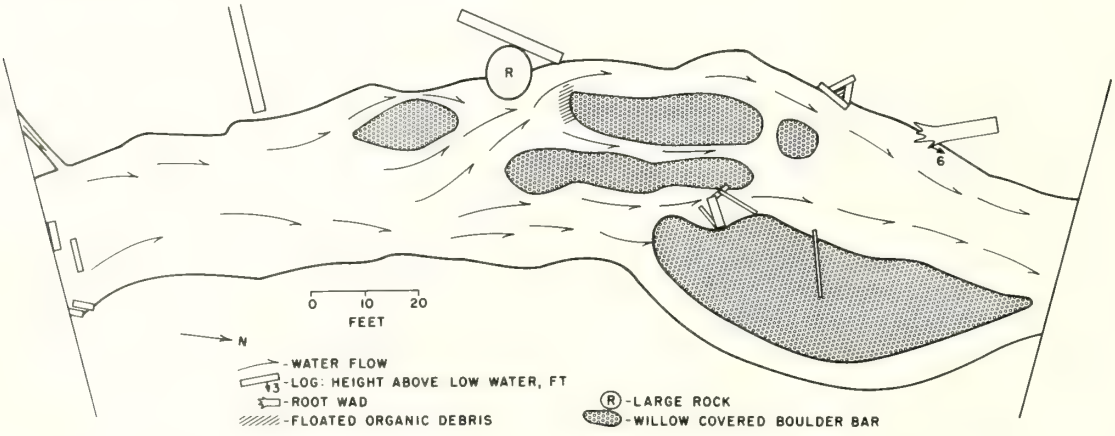

Figure 5.--Map of large organic debris and other material in a 200-ft clearcut section of Mack Creek downstream from sections shown in figure 3 and 4.

the fine debris in the clearcut area was 44 percent of the concentration in the forested stream reach 7 years after logging. The large debris present has practically no influence on sediment storage and the pattern of pools, falls, and riffles. All of the debris in the channel appears to be floatable at high streamflow. Although we do not know channel conditions before logging and roadbuilding, the present appearance and distribution of the debris indicates none of the prelogging debris is in its original position.

Streams in Young Stands

The stream flowing through the 75-year-old stand contains numerous pieces of large organic debris derived from the previous old-growth stand as well as smaller diameter pieces from the postfire stand. The older debris still has an important influence on the movement of sediment and water through the channel. The stream in the 135-year-old stand also contains abundant debris, but pieces from the prefire stand are highly decomposed and have less influence on the stream than debris from the postfire stand. Large organic debris is an important factor in these stream environments even after severe wildfires.

Discussion

The quantity of debris in a stream channel at any time reflects a balance between the processes controlling the debris inputs and outputs of the stream system. Factors which control the input of large debris are age and condition of the surrounding timber stand, the stability and steepness of banks and adjacent hillslopes, and the ability of the stream to transport in new material from upstream channel areas. The export of large organic debris is determined by the ability of the stream to float debris downstream, rates of decomposition and physical breakdown of debris in channels, and the probability of debris torrents flushing out the channel. In many instances input and output take place in sporadic events occurring every few decades or centuries. These include major episodes of blowdown, extreme discharge events, debris torrents, and stream cleanup following logging. In most streams, however, it is a continual give and take situation, with one debris accumulation slowly growing as it traps floated material while the next accumulation along the stream may be collapsing and breaking up into small, floatable pieces after a long period of rotting. It is, therefore, important to view the status of stream debris in a historical perspective.

Several lines of evidence suggest that during premanagement time, small streams have had high concentrations of debris throughout most stages of succession of the surrounding vegetation. Rotting of logs in or above streams is appreciably slower than where they are lying on the ground. Therefore, debris may have a long residence time in the stream environment, possibly remaining in channels well into a second-growth stand developed after wildfire. Flushing of channels appears to be controlled more by slope stability factors (debris slide and earthflow activity within the drainage) than by cycles of debris accumulation in the channel that are terminated by periodic cleaning. These observations indicate small streams draining moderately stable watersheds have contained abundant large organic debris for much of the past few thousand years.

Many of the basic elements of the history and function of large stream debris are clearly seen in the study sections of Zog and Mack Creeks. On the basis of these field studies, we conclude that (1) large concentrations of debris in streams occur naturally; (2) debris may have residence times to more than a century; (3) debris increases the "roughness" of the channel, causing sediment and floated organic matter to be trapped and slowing the movement of these materials through the stream system; (4) a large proportion of the stream drop is in fall over debris, thereby dissipating much of the stream's energy at a few points along the channel rather than more uniformly along the channel as is the case in similar streams which are debris-free; and (5) the impact of large debris on channel morphology is complex because debris causes widening and narrowing, deepening and shallowing, and stabilization and destabilization at different points along the channel bed and banks. On larger streams which can float most of the debris which enters them, the debris plays a rather minor role in the stream environment.

In addition to stream size, the role of debris in streams also varies in response to some factors which change in a roughly systematic fashion from one geographic area of the State to another. For example, many streams in the Klamath Mountains carry heavy gravel loads, but streams draining the sandstones of the Coast Ranges generally contain little gravel. Plant communities also vary between the two areas. Consequently, the concentration, stability, and function of stream debris is likely to vary significantly, necessitating different management strategies. In Coast Range streams, debris might profitably be managed at somewhat higher concentrations to slow bedload movement and enlarge spawning areas; but in sediment-rich Klamath Mountain streams lower levels of debris may facilitate the movement of gravel and reduce aggradation and bank cutting. Such generalities clearly require more study, but they may eventually be useful in developing regional guidelines for debris management.

Clearcutting and cleaning of the stream corridor will have differing impacts under different stream conditions; but, in general, these alterations have three important effects on stream debris: (1) removing large, pre-existing stable pieces of debris from the stream; (2) possibly increasing the concentration of small, unstable debris both by fresh input to the channel and by release of material previously stored behind large debris; and (3) eliminating the source of fresh, potentially stable pieces by removing the timber stand. Consequently, a cleared stream is deprived of coarse organic matter until it is supplied by debris transport from forested sections upstream or until the second-growth stand begins to supply fresh inputs of large debris. This second factor is a long-term proposition which may be short-circuited by frequent cropping of the trees.

What are the long-term consequences of eliminating large organic matter from streams? Of course, it is impossible to answer with certainty; but it seems likely many small streams will undergo downcutting and become effectively "channelized" on bedrock or a stable boulder pavement. A stream which had previously flowed over a series of steps formed by debris will assume a more uniformly steep profile and experience other changes in channel geometry. There will be a resulting decrease in diversity of stream habitat as biologically productive, debris-related depositional pools are eliminated. Increased water velocity will also contribute to the accelerated transport of fine organic matter through the channel system, thereby decreasing the opportunity of stream organisms to process the material. Consequently, the removal of large debris from streams may reduce long-term biological productivity and increase the rate of sediment transfer from headwater streams to downstream areas.

Progressive design and management of logging operations and/or buffer strips (Froehlich 1973, Brown 1974) will help to minimize the impacts of both long- and short-term alterations of the stream environment. Some generalized guidelines, now practiced in many management circles, are:

1) Minimize or eliminate any input of new material to the stream,

2) Base stream cleaning decisions on biological considerations. Money for cleaning to minimize debris torrent hazards in channels might be better spent on improved roads and logging layout,

3) Leave pre-existing, stable pieces of large debris in the stream without disturbing them. This could be done by cruising the channel and marking large stable pieces to be left by the logger. If floatable logging slash does enter the stream, the presence of stable pieces may help minimize the the type of flushing problems described by Rothacher (1959).

4) When considering the trade-offs of buffer strips, recognize them as future sources of large stable debris for the stream. Maintaining buffer strips may help to keep some stream management options open if further study demonstrates in certain situations streamside stands are important as sources of large organic matter for the stream.

The management of massive debris jams presents a special set of problems. There presently seems to be a strong concern to remove jams because, although they do occur naturally, many stand as monuments to past management mistakes. Where jams have trapped large volumes of mineral sediment containing abundant fine material, as is often the case in depositional areas of debris torrents, there are distinct advantages to not removing the large organic debris. The question is often one of releasing a large volume of sediment over a few years or allowing it to be naturally, slowly routed downstream over much longer periods of time.

With both moderate and excessive debris loads in streams, there is no single, simple set of rules which can be applied indiscriminately throughout western Oregon. Each site presents a different set of conditions of stream biology, channel gradient, status of stream debris, conditions of surrounding timber stand, abundance and size of bedload, and slope stability in the drainage. The great complexity of the stream environment means each site must be inspected in the field and treated on an individual basis. Debris management problems call for a high degree of cooperation between specialists and administrative personnel.

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